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VOL. XXIV. JULY, 1899. No. 1

BIOGRAPHICAL SKETCH OF GEORGE CLINTON SWALLOW.

By G. C. BROADHEAD, Columbia, Mo.

George C. Swallow was born at Beckfield, Oxford Co., Maine, A. D. 1817. After more than a year of declining health, he died at the home of his daughter, Mrs. Anna P. Woolfolk, in Evanston, Ill., April 20, 1899, aged 82 years. He was descended from a Norman-French family who spelled their name Sevallieu. His ancestors came over to England with William the Norman. Prof. Swallow was married to Miss Martha Ann Hill, March 17, 1844. She died at Evanston in the year 1898. They were both buried in the cemetery of Columbia, Mo., in which town they had lived for many years. They left one daughter, Mrs. Anna P. Woolfolk, wife of Col. A. M. Woolfolk, formerly of Missouri, but for a number of years a resident of Montana, and at present residing at Evanston, Ill.

Prof. Swallow was a little over six feet high and weighed over two hundred pounds. He was a handsome man, with a large full eye. During his active life he was lively and fond of joking, and during his residence in Columbia he had many friends. He became a member of the Presbyterian church in early life and was, for a number of years, elder in the church in Columbia. He was also elder of a church in Montana.

In receiving an education Swallow's chief aim was the study of natural history and natural science. He studied geology, chemistry, botany and zoology with Prof. Parker Cleveland for five years and graduated at Bowdoin college in 1843. He also took a course in medicine as a science. The first year after graduation he was chosen to give a course of lectures on botany as applied to agriculture and mechanic arts to the senior class of Bowdoin college. From 1843 to 1849 he was principal of Brunswick female seminary. In 1849 he was principal of Hampden academy, Maine. In 1849-50 he was a member of the state board of education of Maine, and was school commissioner of Hampden.

From 1845 to 1850 inclusive he was teacher and lecturer at various teachers institutes of Maine, including the counties of Cumberland, Waldo, Lincoln, Aroostook, Penobscot, etc. In 1849 he was invited to take charge of Farrington academy, and in 1850 to take charge of Oldtown academy. In 1851 he was re-elected school commissioner of Hampden county for three years. In 1851 he was also invited to take charge of Schoharie academy in New York. In 1851 he was elected a member of the board of education of Hampden by a vote of 34 to 2.

In October, 1851, G. C. Swallow was elected to fill the chair of chemistry, geology and mineralogy in the university of the state of Missouri. On the 8th day of December he started for Missouri and reached Columbia in the latter part of the month. January 1, 1852, he began his labors in the state university, and on the 14th gave his first lecture to the class. He speaks well of the laboratory equipment at that time and praises his class.

April 2, 1853, Swallow was appointed state geologist of Missouri, and on the 6th of June he resigned his place in the state university.

In 1856 he declined the appointment of professor of chemistry and natural sciences in Westminister college, at Fulton, Mo. In 1857-58 he acted as professor of chemistry and natural sciences in the university of Missouri, dividing his time with the geological survey. In 1861 the state geological survey was discontinued. In 1864 G. C. Swallow was assistant geologist of Kansas, and in 1865 he was appointed state geologist of Kansas, and was for two years engaged on the Kansas survey. From 1867 to 1870 he was superintendent of mining operations at Highland, Montana.

In 1870 Swallow was again employed by the university of

Missouri, being appointed professor of agriculture in the Agricultural and Mechanical college. In 1872 he was dean of the Agricultural and Mechanical college. Dec. 10, 1872, he was also professor of botany, comparative anatomy and physiology in the medical school of the university of Missouri. He was professor of natural sciences and dean of the Agricultural and Mechanical college up to 1882. From 1882 to 1890 Prof. Swallow resided at Helena, Montana, and in 1888 was appointed by the governor inspector of mines, which office he held for two years, and, although the position was again offered him, he declined it.

Prof. Swallow was an industrious man all of his life. His father was a farmer and also a manufacturer of implements, and the son, when at home, worked on the farm in the summer and in the shop during winter. These pursuits, no doubt, helped him very much in his labors of later years. He was a very close observer of all natural phenomena; his eye missed but little that was of interest or important to know. This I have observed during his geological work, for each stratum was observed carefully, though rapidly, both as regards its position and connection and correlation with other layers, and its color, texture, hardness, fracture, weathering, mineral contents, composition and fossils. The general surface and topography of the country were also noted with care. His assistants were quick to adopt his methods and to recognize their value. Furthermore, every object of natural history belonging to the country was observed. The animals were noted, the shells, both land and freshwater, and the reptiles. The flora was closely observed and specimens of plants collected. The trees were catalogued as to size and distribution; the soils were collected and the growth of plants and trees peculiar to each kind of soil was noted. Many useful notes were taken, but alas, by the stopping of the survey in 1861 these were rendered useless, as they were never published.

At the Indianapolis meeting of the American Association for the Advancement of Science in 1871, Prof. Swallow was chairman of "Section B," and delivered an address on Missouri geology. This induced the geologists present to join in a memorial to the Missouri authorities to publish Swallow's notes as prepared by him. This memorial was signed by nearly all of the foremost geologists of the United States, but it had no effect and the notes remained unpublished.

Prof. Swallow's idea was to carry out a plan for a survey similar to that just before pursued in New York. It was a grand idea, but failed on account of the survey being stopped. His geological subdivisions were right in their order and detail, although the nomenclature in one or two places was not entirely with that of the present day. But it was fully up to the highest standard of the time. None of it was wrong. No other man during the same length of time has ever gone into a strange field, traversed the country and published a volume, all in a year and a half, as he did. In that time he delineated very nearly the boundary of our coal fields, and showed where the various geological formations existed. His work stands the test well.

Swallow's work in Missouri was about as follows: In June, 1853, he made detailed geological examinations in Boone county. In July he was absent in the East for the purpose of securing instruments for the survey. Aug. 26, 1853, he left St. Louis on the steamboat Robert Campbell for Council Bluffs, Iowa. Between Sept. 14 and Nov. 5 he and his party came down the Missouri on a skiff from Council Bluffs to Rockport, nearly 500 miles. On this route he observed many sections of strata which were afterwards published. During December, 1853, with several men and a team he made an overland trip to southwest Missouri, examining the strata at many places. The winter was occupied in office work, examination of specimens collected and preparing his reports. In 1854 he visited the extreme southwest, central Missouri and the northeast.

Professor Swallow's Publications.

First Annual Report, of 1853, briefly gives information of what work had been done.

Second Report, Dec. 1, 1854, includes published details of the work done by himself and his assistants; of himself 207 pages, assistants 239 pages; including 15 plates, 3 plates of fossils, 5 maps, 11 figures and 42 sections. This was the result of 18 months of field and office work.

In 1859. Published "Geological Report of the Southwest Branch of the Pacific Railroad," 98 pages. The chapter of this report on Grape Culture was translated into French and circulated in France. Each year while he was state geologist, Swallow published a pamphlet of a few pages giving report of progress.

In 1866. A preliminary Report of the Geological Survey of Kansas, including 94 pages of Swallow's work and 94 pages of work of assistants.

Other papers of Prof. Swallow, were:

Description of new fossils from the Carboniferous and Devonian of Missouri, in the Trans. St. Louis Acad. of Sciences, 20 pp. in Vol. 2, 1860.

On some new varieties of Spirifer, published in 1860 in Trans. St. Louis Academy of Sciences, Vol. 2, pages 408-10. 3 pages.

Remains of Horse in altered Drift of Kansas, Vol. 2, Trans. St. Louis Acad. of Sciences, 1866, one page.

Review of Meek & Hayden's notes on "Preliminary Report of Kansas," April, 1868, in Vol. 2, of Trans. St. Louis Academy of Sciences. 19 pages.

1874. In Campbell's Gazetteer of Missouri. On the Physical Geography of Missouri. 39 pages. Also published, 1878, in Swilgler's History of Missouri. St. Louis.

1874. In Campbell's Altas of Missouri, 10 large quarto pages (atlas size) and 2 plates on the geology of Missouri.

1878. Co-education, Vol. 2, Kansas City Review, April.

1857. Indian Mounds in New Madrid County, Mo., in Trans. St. Louis Ac. of Sciences, Vol. 1, Feb., 1857. 1 page.

Notice of the Discovery of Permian in Kansas. Trans. St. Louis Acd. Sciences, Feb., 1858.

Grape Culture. Trans. St. Louis Ac. Sciences, 1858.

Description of Devonian and Carboniferous fossils. Trans. St. Louis Ac. Sciences.

Swallow and Hawn, Rocks of Kansas in Trans. St. Louis Ac. of Sciences, Feb. 22, 1858.

March 8, 1858, Rocks of Kansas and Description of new fossils from the Permian of Kansas, Trans. St. Louis Acad. of Sciences, Vol. 1, 1858. 25 pages.

Shumard and Swallow. Description of new fossils from the Coal Measures of Missouri and Kansas. Trans. of St. Louis Acad. of Sciences, Vol. 1, March 8, 1858.

1880. Evolution and Creation, Vol. III, Kansas City Review, Jan. and Feb.

1892(?) Report of Mine Inspector of Montana.

Degrees, Member of Societies, Etc.

1856. Corresponding member of St. Louis Academy of Sciences.

1856. Corresponding member of the Imperial Geological Society of Vienna, Austria.

1857. Honorary Member of Acad. of Sciences, San Francisco.

1857. Honorary Member of the Acad. Sciences, Chicago.

1858. Member of the American Association for the Advancement of Sciences.

1859. Honorary Member Historical Society of Iowa.
1859. Honorary Member Acad. Natural Sciences, Philadelphia.
1856. Honorary Member of the Historical Society of Wisconsin.
1859. Honorary Member of Cleveland Nat. His. Society.
1860. Honorary Member of Historical Soc. of New Mexico.
1871. Chairman of Sec. B., Am. Assn. Adv. Sciences.
1872. Delegate of Agl. & Mechl. College of Missouri to represent it at the Convention at Washington City.
1872. Degree of M. D. from the Missouri Medical College.
1872. Degree of LL. D. from Missouri State University.
1866. Member of Essex Institute.
1866. Honorary Member of Maryland Historical Society.
1889. Fellow of the American Geological Society.
1891. Membre Congrès Géologique International.

THE GREAT ICE-DAMS OF LAKES MAUMEE, WHITTLESEY AND WARREN.

By Frank Bursley Taylor, Fort Wayne, Ind.

(Plates II and III.)

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INTRODUCTION.

During the retreat of the ice-sheet across the region of the Great Lakes their natural courses of drainage were temporarily obstructed. The glacier ice was so thick and solid that, although it was constantly advancing slowly forward, it fitted itself the while so closely to the ground over which it passed that it constituted a dam or barrier as impervious and impassable for water as the solid, rocky range of the Laurentides. In the valleys and basins so obstructed, the water from melting ice and snow and from rain gathered and formed into lakes. Each lake stood at the level of the lowest point on its rim and this became its outlet or place of overflow. With continued retreat, the first small lakes expanded their boundaries over the newly uncovered ground and with the opening of new outlets their surfaces dropped to lower and lower levels. Lakes in descending series began in this way in several basins probably almost simultaneously. One of the earliest began with a comparatively small lake at the head of the Maumee valley in Ohio and Indiana and spread from that over the whole of the Erie and parts of the Huron and Ontario basins. It is of the history of this series, with special reference to its great ice-dams, that this paper is designed to treat.

Peculiarities which characterize causes are generally more or less manifest in results and are often the main reliance in analysis. Thus, certain peculiarities which characterized the glacial retreat and exercised a marked influence upon the glacial lakes may now be used as keys to the lake history. A clear perception of them at the start will simplify the story and be a material aid in the following presentation.

Retreat of the Ice-sheet.

The retreat of the ice-sheet was not a simple drawing back at a steady, uniform rate, but was an oscillating movement and apparently periodic, as though alternating two steps back and one forward, two back and one forward, continually. Wherever the ice-front stood for a time at one line, it dumped its detrital load and built a more or less defined ridge or terminal moraine. In the general retreat of the ice-sheet the moraines built at the climaxes of readvance were left standing, while those built at the alternating climaxes of retreat were always overridden and destroyed. Thus, the "moraines of recession," as those now found in consecutive series are called, show by the rhythm of their intervals the periodic nature of the oscillations of the receding ice-front. Fifteen moraines in series occupy the interval between Cincinnati and the straits of Mackinac, and there are seventeen between Cincinnati and Rochester, N. Y.*

It is obvious that the rhythm of retreat was not local. It was not confined to any one lobe or basin, but was continental or hemispherical or, more probably, terrestrial in extent. Rightly understood, this rhythm of the moraines is of incalculable value in the study of glaciation, and nowhere is it more so than in the study of the glacial lakes. It furnishes the key for the correlation and identification of moraines and ice-dams in different basins and in areas far apart. Where two sets or series of moraines are clearly defined in two adjacent basins, if the contemporaneity of any particular moraine in one basin with a particular moraine in the other can be clearly made out, then the correlation of the whole of the two sets into contemporaneous pairs may be accomplished. Of course, the simpler the series and the more clearly the relations are defined the more reliable will the correlation be. But there are two situations in which, with the individual moraines of the series clearly marked, precise correlation becomes absolutely sure. One is where a symmetrical lobe of the retreating ice-sheet divides around some highland mass into two distinct and clearly separated lobes; the other is where two such lobes retreat into one basin and become united into a single symmetrical lobe. If the moraines, after separation in the one case or before union in the other, form two clearly defined series continuous with that of the single, symmetrical lobe, then correlation between the members of the two branches is perfect. Fortunately, a good example of each kind occurs within the area here considered. The very symmetrical Maumee ice-lobe divided into two parts as it retreated, one receding down the basin of lake Erie and the other up the Detroit-St. Clair valley. The latter part united at a later stage with the Saginaw lobe in the basin of lake Huron. When the Erie lobe had retreated as far as the western end of lake Ontario, it separated from the Georgian Bay lobe. The moraine series of the Saginaw and Georgian Bay lobes have not yet been fully explored.

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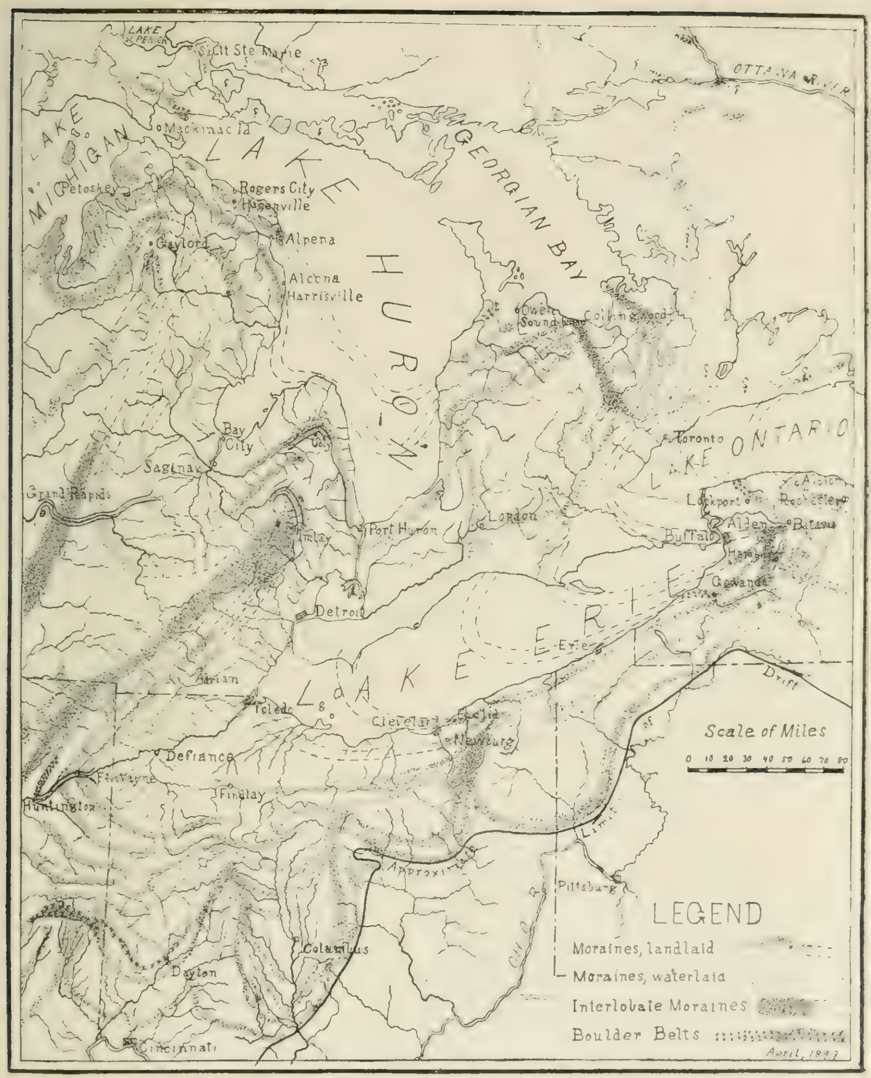
*The character of the oscillations and their probable cause are discussed in a previous paper entitled "Moraines of Recession and their Significance in Glacial Theory." Jour. of Geol., vol. v, No. 5, July-August, 1897.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Sault Ste Marie
OTTAWA RIVER
LAKE MICHIGAN
Mackinac Id
LAKE HURON
GEORGIAN BAY
Petoskey
Rogers City
Hagenville
Alpena
Gaylord
Alcona
Harrisville
Owen Sound
Collingwood
Toronto
LAKE ONTARIO
Bay City
Saginaw
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Adrian
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Euclid
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Defiance
Ft Wayne
Huntington
Findlay
Approximate Limit of Drift
Pittsburg
Columbus
Dayton
Cincinnati
Scale of Miles
0 10 20 30 40 50 60 70 80
LEGEND
Moraines, landlaid
Moraines, waterlaid
Interlobate Moraines
Boulder Belts
April, 1899

Fig. 1.

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But the series from Cincinnati to Toledo and thence by two branches to Mackinac straits and Rochester, N. Y., are believed to be complete.

Guided by this theoretical outline of the glacial recession, the story of the lake history is greatly simplified. For by following up the related pairs of moraines in the two diverging series, the successive positions of the great ice-dams may be easily noted in close connection with the principal concurrent changes of area, outlet and level which took place in the contemporary lakes.

Theoretical Relations of Ice-dams, Outlets and Beaches.

A word or two on the theoretical relations between ice-dams, outlets and beaches will give a clearer setting to the facts to be considered later. As it moved over the uneven country, the plasticity of the glacier caused it to yield readily to the influences of topography. Elevated areas of land held the advancing ice-front back. The ice pushed forward in the wide, open valleys and lagged behind on the intervening highlands. Thus, the line of the ice-front was made uneven; lobes projected forward in the valleys and re-entrant angles set back upon the hills.* New outlets were opened only as the retreating ice uncovered lower ways of overflow at the sides of the basin. The moment a passage lower than the water surface was opened on either side across the retaining land barrier, the water rushed through and a new outlet was established. If the new outlet stood at the same level as the old one the discharge would be divided between them and the lake would thereafter have two active outlets, but if the new outlet stood much lower it would take the whole discharge. In either case the surface of the lake would fall to a lower level and a new beach would begin to be formed.

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*It should be borne in mind that whether the ice-front was retreating or advancing, the ice itself was always moving forward. Thus, topography modified the line of the ice-front during movements of retreat in precisely the same way that it did during forward or advance movements.

Note to Fig. 1. In New York, Pennsylvania, Ohio and Indiana the moraines are shown as mapped by Leverett. In northwestern Ohio they follow the earlier work of Gilbert and N. H. Winchell and in northeastern Indiana that of Dryer. In Michigan, except along the eastern border, the mapping follows Chamberlin. The writer's contributions are mainly along the eastern border of Michigan and in Ontario. The hypothetical continuation of moraines across the water-filled lake basins and across certain regions which remain unexplored, or where the identity of the individual moraines is doubtful, are represented by two parallel broken lines. The several old outlet channels are shown by pairs of heavy parallel lines.

It is a necessary consequence of the general relations involved in the retreat of the glacier that whenever a new outlet was first opened the ice-front was always present just then at that place and not somewhere else miles away. The first outflow was always close along the edge of the ice, so that now, where an old outlet channel is found running close along the front of one of the moraines of recesion, it follows that the ice-front stood just there while the outlet stream was flowing at its base, and if that moraine be traced continuously across the lake basin it will show the precise position which the ice-dam occupied at that time. But even if the moraine be not traceable, the emerging place of the dam on the other side of the basin may be determined by a correlation of the moraines in the series as pointed out above. And where a lake was sustained by two ice-dams, their contemporary positions may be found in the same way. Where the outlet crossed a hill or ridge which separated the lake basin from an adjacent valley with lower drainage and where the ridge sloped downward in the direction of the ice retreat, there was a tendency for the outlet to hug the ice-front in the re-entrant angle. Good examples of this relation are found in the area here considered.

The close relationship between new outlets and moraines of recession furnishes a basis for the approximate determination of another important matter. It furnishes the data for determining theoretically a definite limit beyond which the beach or shore line of the next preceding lake stage cannot extend. For at the opening of a new outlet, all or a part of the discharge through the old one must have ceased and the surface of the lake must have fallen to a lower level. The beach associated with the old outlet was then abandoned and the formation of a new one begun on a lower plane. It follows, therefore, that the moraine associated with the new outlet marks the extreme possible limit of extension of the beach associated with the old outlet. This beach could not extend beyond the new outlet on the one side of the basin, nor beyond the emerging place of the same moraine on the other side. It would be expected, however, that the beach on both sides would grow fainter towards its points of termination, and this would result from two causes. Where the lake basin was wide and had gentle side slopes the emerging places of the ice-dam would be far back on the sides of the lobe, so that the lake would run back on the two sides for many miles as long narrow arms between the land and the ice-front. Such an arm might be fifty or seventy-five miles long and average as little as ten or even five miles wide. In such a situation wave action would be less effective than in the open lake. And further, the fact that the shore of such an arm would be newly uncovered ground where the waves had had only a comparatively short time to act would also contribute to the weakness of the beach produced. Whether a beach shall fade out gradually or end in stronger form and more abruptly, depends also in large measure upon the relation of the new outlet to the oscillations of the glacial retreat. While the ice-front stood at one of its halts the beach of the lake at that stage would have time to be formed in some strength, close up to the moraine, and if a new outlet were opened immediately on withdrawal from that moraine faint extension of the beach would never take place. Faint extension is favored most when the new outlet is not opened until just before or at the next halt and at the close of an active movement of retreat. This relation generally obtains where the outlet lies close along the face of a moraine.*

The foregoing theoretical considerations are not imaginary, but are based on known facts. We know from the moraines of recession that the glacier retreated across the Erie basin in a certain manner. We reason, further, that if the glacier acted as a great dam and the moraines mark its successive halting places, then certain changes and relations affecting the waters held in front of the ice must have followed substantially as pointed out above. It remains now to describe the things which have actually been observed and see how far the facts agree with theory.

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*An important factor of the lake history must also have arisen from the readvances of the ice-front during the oscillations of the general retreat. Outlets may sometimes have been opened for a short time and closed again and the level of the lake temporarily raised by a readvance of the ice. Or, when no outlet was involved, a beach formed during extreme retreat might be encroached upon later by readvancing ice, and moraines might thus be left in positions which would show conclusively that this had happened. Actual evidences of such readvances have been found at several places, but for the purpose of the present paper a discussion of this interesting phase of the glacial retreat is not essential and is therefore omitted.

Moraines of Recession in the Lake Basins.

The precise location of the ice-dam at different stages of its recession is made possible only by the existence of the moraines of recession. They show the successive positions at which the ice-front halted and thus furnish information far more definite and accurate than any that could be gathered from a monotonous drift sheet without terminal moraines. It was therefore necessary to trace the moraines that cross or descend into the lake basins before the precise place of the ice-dam at any stage could be known. Mr. G. K. Gilbert took the first step in this direction in 1870, when he made a geological survey of the Maumee valley. He found a terminal moraine of the glacier passing just east of Defiance, O., and curving thence south and southeast past Findlay and north and northeast past Adrian, Mich. Defiance is at its apex and this moraine is now known as the Defiance moraine.* This moraine spans the Maumee valley from side to side completely and marks, as we now know, the first position of the ice-dam in the Erie basin. Although Mr. Gilbert did not at that time recognize it as marking the place of an ice-dam, its significance in this respect was made plain on the publication of Dr. J. S. Newberry's hypothesis of ice-dams.†

For many years this moraine stood as the only one that had been traced continuously across a lake basin and hence marked the place of the only ice-dam that had been accurately located. The lake held in front of this dam will be described later on.

The Erie-Ontario Series. With the early acceptance of Dr. Newberry's hypothesis a new field of investigation was opened. If his view was correct, then the abandoned beaches of northern Ohio were the remains of glacial or ice-dammed lakes. The possibility of discovering some definite relation or connection between the ice-dams and the beaches became at once an attractive theme. Mr. Gilbert took up the subject again and explored the coast along the south side of lake Erie into western New York, with results and conclusions which are summarized in the following quotation from an article by Mr. Frank Leverett, published in April, 1892.

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*Its course is well shown on Mr. Gilbert's map of the Maumee valley in the "Geology of Ohio," vol. I, 1873, opposite page 541. In vol. II of the same survey, 1874, p. 432, N. H. Winchell calls this moraine the "Blanchard ridge," and he also calls the moraine which passes through Fort Wayne, Ind., the "St. Mary's ridge." These names were taken from rivers that flow along the front of the moraines in the southern half of the valley, but in the northern half there are other rivers in the same relation to the same ridges. The completion of the moraine series northward to lake Huron disclosed the fact that there is a well known city at or near the apex of each moraine. These names are better known and are more easily understood as applying to the whole extent of each ridge on both sides of the valley. Thus we have the Fort Wayne, Defiance, Toledo, Detroit and Port Huron moraines.

†"Geology of Ohio." vol. II, 1874, pp. 8 and 51-52.

"Some years ago Mr. Gilbert discovered that several of the raised beaches of Lake Erie do not completely encircle that body of water, but terminate in a successive series from higher to lower in passing eastward from northern Ohio to southwestern New York. The results of his study are unpublished, * * * In explanation of the termination of these beaches, Mr. Gilbert has entertained the theory that they represent successive positions of the ice-front in its northeastward retreat across the Lake Erie basin, but has held that the complete verification of this theory depends upon the occurrence of moraines which are demonstrable correlatives of the beaches."*

The next substantial advance toward the precise location of the ice-dams was made by Mr. Leverett, who studied the moraines of Ohio and their relations to the beaches in 1889, 1890 and 1891. He followed the Defiance moraine from near Findlay eastward to the hills southeast of Cleveland, where he found two other moraines between it and the present lake shore. The first one (the second from the shore) is strong as far west as Newburg about five miles southeast of Cleveland, but fades out at North Linndale southwest of the city, where it passes below the level of one of the old lake beaches. This is called the Newburg moraine.

The second moraine, lying at a somewhat lower level and nearer the lake shore, fades out westward at Euclid about ten miles east-northeast of Cleveland. This is called the Euclid moraine. The close proximity of the three moraines near Cleveland is due to the fact that they are banked up on the comparatively steep slope of the escarpment which faces the lake at that place.

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*"On the Correlation of Moraines with Raised Beaches of lake Erie." Am. Jour. Sci., 3rd series, vol. XLIII, April 1892; p. 284. This paper presents an account of Mr. Leverett's work on the moraines and beaches of Ohio.

In 1893 Mr. Leverett carried his studies farther east along the lake shore into western New York.* Along the steep coast as far as Westfield, N. Y., the Euclid moraine runs in an almost even line only a few miles back from the lake shore. East of Westfield, however, it runs farther inland past the village of Dayton and thence northeast to a point about 30 miles southeast of Buffalo, where it joins an interlobate moraine, which trends north and south. The next member of the series starts from the interlobate west of Attica and runs southwest to Gowanda, where it changes to a bowlder belt running west as far as Forestville and apparently fading in that direction into the old lake bed. This may be called the Gowanda moraine.

Starting from the interlobate a few miles farther north is another moraine which runs west-southwest to Hamburg, where it, too, fades away at the old lake level. This is called the Hamburg moraine. Farther north Mr. Leverett found still another running a short distance west towards Buffalo from the interlobate and fading out near Alden, by which name it is designated.

The next moraine of the series trends northwest and southeast passing just north of Lockport and Batavia. This Mr. Leverett calls the Lockport moraine. Towards the northwest it descends over the Niagara escarpment and runs thence as a bowlder belt to the shore of lake Ontario into the basin of which it appears to pass.

The next and last one of the series so far made out runs west from Rochester to Albion and probably also descends into the lake bed. This moraine has since been identified by Prof. H. L. Fairchild with the Pinnacle hills just south of Rochester. It is called the Albion moraine.

These seven moraines were made during the recession of the Erie-Ontario lobe of the ice-sheet and it is believed that the first five of them are the precise correlatives of a similar series found by the writer in Michigan and Ontario in 1895, 1896 and 1897.

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*"On the Correlation of New York Moraines with Raised Beaches of Lake Erie." Am. Jour. Sci., vol. L, July, 1895.

The Erie-Huron Series. In exploring the "thumb" of Michigan in 1896, the writer found three moraines in series in the area west and northwest of Port Huron.* All the moraines of southeastern Michigan and northern Ohio show a marked change in character below a contour of about 200 feet above the lake. They have the ordinary rolling topography of landlaid moraines above that level, but below it they are all much subdued in their relief. Some are so flat and wide that their existence as a ridge is hardly noticeable, but even then their influence upon the drainage is very marked in most cases and this circumstance is a help in tracing them. Their subdued expression below 200 feet is due to the fact that they were laid down at the edge of ice-lobes standing in the water of the glacial lakes. The three moraines referred to all become waterlaid southward from the parallel of Port Huron. One of them runs southeast from the vicinity of Marlette and turns south past Imlay City on the east. Southward it becomes waterlaid and much subdued, but was faintly traceable passing about ten miles west of Mt. Clemens and fifteen miles northwest of Detroit and on nearly to Toledo. Its course points to Toledo as being at or near its apex, and so it has been called the Toledo moraine. On noting the relation of this moraine to those next west of it, it was found that in the southeast corner of Michigan, where the relations are plainest, the next one on the west is the Defiance moraine which passes through Adrian.

Near Port Huron the next moraine east of the Toledo was found well developed in landlaid form running south past the east side of the village of Yale. Thence it runs south close west of Mt. Clemens to the city of Detroit and there crosses the Detroit river to the southern side of Essex county in Ontario. This has been called the Detroit moraine.

The next moraine near Port Huron is one that occupies a very prominent position. It skirts the entire shore of the south arm of lake Huron and Saginaw bay and is strongly developed and clearly separated from the other moraines of the region.

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*"Correlation of Erie-Huron Beaches with Outlets and Moraines in southeastern Michigan." Bull. G. S. A., vol. 8, 1896. This paper gives an account of the beaches, outlets and moraines on the "thumb" and in the Saginaw valley, and is accompanied by a map.

It is a finely formed landlaid moraine on the thumb and is easily traceable continuously in its waterlaid form across both the St. Clair and Saginaw valleys. Indeed, in both these valleys it may be taken as a type specimen of a waterlaid moraine. It runs south from Ubly, forming the divide between Black river and lake Huron, and passes close west of Port Huron, its crest crossing the St. Clair river about a mile north of St. Clair Springs. Three miles northeast of Ubly it turns an angle of 75° or 80° and runs thence southwest along the north side of Cass river, forming the divide between it and Saginaw bay. Then it curves westward, passing through the city of Saginaw, and then northward and northeast to the Au Sable river, making the entire circuit of the bay about twenty miles back from the present shore. Its influence upon the drainage is remarkable and is well shown in the courses of the Maitland and Sable rivers in Ontario and the Black, Cass, Tittibawassee and Au Sable in Michigan. Where it crosses the last named river it turns toward the northwest and passes farther inland. This has been called the Port Huron or Port Huron-Saginaw moraine. There appears to be no other moraine between it and the present lake shore in Michigan until after passing north of the Au Sable river.

Another strongly developed moraine appears to be cut off at the shore in the vicinity of Harrisville and Alcona and runs thence northwest. This has been called the Alcona moraine. Farther north another, which runs in the same direction from near Alpena through Hagenville and past Rogers City on the south, is called the Hagenville moraine.

Another moraine north of the straits of Mackinac runs through Les Chenneaux islands and a range of hills about five miles north of Hessel, its course from the shore being about west-northwest. It is not known at present whether this is the next moraine in series or whether there may not be another between it and the Hagenville. No evidence of such a moraine, however, has yet been found. Two other moraines farther north are doubtfully identified, one passing through Drummond, Cockburn and St. Joseph islands and the other skirting the shore a few miles back of the North channel of lake Huron. Not counting the last three, the series is believed to be complete as far as the Hagenville moraine, which is the fifth north of the Toledo, counting the latter as first.

In 1897 the writer made a reconnaissance of most of the area bordering the east side of lake Huron south of Georgian bay and found there the continuation or complementary parts of four of the Michigan moraines. The Detroit moraine was traced nearly 200 miles and the Port Huron about 150 miles from the St. Clair river. Southeast of Point Clark both of these turn towards the northeast running in roughly parallel lines. North of this part of the Port Huron moraine two others were found also running in the same direction. The first one corresponds to the Alcona moraine of Michigan. It passes close north of Lucknow, Walkerton and Hanover. The second begins northeast of Point Clark, passes close north of Chesley and Holland Center and corresponds to the Hagenville moraine in Michigan. All four of these moraines trend northeast towards the promontory of Blue mountain west of Collingwood. Part of a fifth moraine still farther north was seen between Southampton and Allenford, but its course was not certainly made out.

Here, then, is a consecutive series of five moraines of recession running north from the same starting point as that of the similar series of seven which Mr. Leverett found running towards the east. By beginning at the point of common origin and setting off the successive pairs of moraines in the two series, we are enabled to note accurately the location of the ice-dam at each step of its retreat.

Location and Dimensions of the Ice-dam at its several Halting Places.

The Defiance Dam. The Defiance moraine shows that the ice-dam at that stage presented an evenly curved front, such as is characteristic of a single, simple ice-lobe. Nevertheless, it is certain that this particular lobe was compounded of two united ice-streams coming from different directions—from the Erie and Huron basins respectively. Some time before reaching Defiance, however, the two streams had evidently become perfectly blended in one, so that the dual source of the lobe was no longer expressed in its frontal form. When it stood at the Defiance moraine, the ice-dam was nearly 100 miles long and the water at its apex was about 60 feet deep.

The Toledo-Newburg Dam. The next moraine in the

Michigan series is the Toledo and the next in Mr. Leverett's series is the Newburg in the southern part of Cleveland. It can hardly be doubted that these are parts of one moraine. At Newburg the moraine begins to descend westward to one of the beaches and soon fades away in the old lake bed. It has not been traced toward Toledo, and the character of the intervening country suggests that it may not be possible to follow it. In this case, however, not only does our scheme of correlation suggest the union of these two parts, but the completion of the Toledo moraine in Ohio by extension from Michigan in accordance with the laws of the adjustment of the ice-sheet to topography would plainly carry its front around in a great curve from Toledo towards Cleveland. Toledo is on the axis of the basin and such a curve is required to complete the symmetry of the lobe in conformity to the symmetry of the basin. It seems certain, therefore, that the two ice streams were blended into one lobe at the Toledo moraine also. At this time the ice-dam was about 230 miles long and stood at Toledo in water which was nearly 200 feet deep.

The Detroit-Euclid Dam. At its next position in Michigan the ice-front stood at the Detroit moraine, and this appears to be the correlative of Leverett's Euclid near Cleveland. In this position the ice-dam made a more direct line across the basin and so was probably not over 200 miles long. The direction of the Detroit moraine seems to indicate quite clearly that at this stage the two ice streams were not united in one symmetrical lobe-front, but were simply in contact along their contiguous edges for 70 or 80 miles. The Detroit moraine, after crossing to the southeastern part of Essex county, Ont., runs northeast along the north shore of lake Erie and south of the Thames river to London, Ont., where it turns directly north for about 75 miles. The course of the Euclid moraine in crossing the bed of lake Erie is not known, but in all probability runs west from Cleveland, curving around gradually towards the north so as to meet the Detroit moraine somewhere south or southeast of lake St. Clair. From this point to London the lobes were in contact and probably more or less blended. But at London the moraines separate, the Detroit passing north, as just stated, around the west side of the highlands south of Georgian bay, while the Euclid moraine was found continuing toward the northeast and north around the east side of the same highlands, at the north side of which the two undoubtedly become again united. Thus, in central Ontario, between lake Huron and lake Ontario, a large area of the highlands was left as an insular tract surrounded on all sides by the ice-sheet and having its only possible way of drainage toward the southwest along the line of contact between the two lobes. The general slope of this insular area is in a southerly direction and it is probable that while the higher northern part of it was dry land, a lake of some size covered its southern portion. The existence of this lake has not been established by observation and is only suggested here as a logical probability following from the observed position of the moraines and the certainty that the ice in the confluent lobes was at least several hundred feet thick. At its apex the Detroit dam stood in nearly 200 feet of water, while the Euclid in the bed of lake Erie stood in hardly less than 240 or 250 feet.

The Port Huron-Gowanda Dam. At its next position in Michigan the ice-front stood at the Port Huron moraine and in Leverett's series at the Gowanda. The two ice-lobes had now separated entirely, leaving a distance of about 50 miles between their adjacent limbs in southern Ontario. At this and the two succeeding stages the lake in the Erie basin was held in by two great dams. The Port Huron dam was nearly 200 miles long and stood in about 150 feet of water at its apex. The Gowanda dam was probably much longer and its point probably stood in something like 400 feet of water. The line of the latter dam is less clearly indicated than any other of the series and the place of its apex can only be conjectured. As indicated by the positions of the dams preceding and following it, however, it seems probable that its apex was about in the center of lake Erie, 40 or 50 miles west of the meridian of the Ohio-Pennsylvania line. At this time there was also a lake in the Saginaw valley and its retaining dam stood on the Saginaw moraine in nearly 150 feet of water and was about 125 miles long. At this stage of the retreat the insular area in Ontario had grown somewhat larger. For the ice had drawn away from the southern half of its boundary and left that side facing the open lake, although the ice still walled in its northern sides.

The Alcona-Hamburg Dam. The next halt of the ice-front in Michigan was at the Alcona moraine, and this seems to correlate with Leverett's Hamburg moraine in western New York. The ice-dam in the Huron basin at this time was something over 200 miles long and at its apex stood in water nearly 500 feet deep. The Hamburg dam was probably somewhat longer and its point stood in about 450 feet of water. The island of the Ontario highlands still remained, but had been slightly enlarged by the drawing back of the ice and by a fall of more than 100 feet in the level of the lake waters along its southern shore.

The Hagenville-Alden Dam. At its next halt the ice-dam stood at the Hagenville moraine in Michigan and at the Alden moraine in New York. In the Huron basin the dam was perhaps a trifle longer than in the preceding position and its apex stood in water about 50 feet deeper. The Alden dam was probably not more than 150 miles long and its forward part stood in water not more than 300 feet deep. The Alden dam is believed by the present writer to have stood along the north side of the lower course of Grand river in Ontario, turning north and northeast around the western end of lake Ontario. Observations tending to that conclusion were made at three points on the supposed course of the moraine by the writer in 1897, but owing to its being waterlaid its recognition is not certain without further and more connected tracing.

The Lockport Dam. The next halt of the ice-front in New York was at the Lockport moraine. No correlative for this moraine has yet been identified with certainty in the Huron basin. The Lockport moraine is probably, but not certainly, identified with a moraine on the opposite side of lake Ontario running northeast from Scarboro Heights a few miles east of Toronto. If this surmise is correct the dam could hardly have been less than 100 miles long and its apex must have stood in water nearly 1,000 feet deep.

The Albion Dam. At its next rest in New York the ice-front stood at the Albion moraine. Nothing corresponding to this has been reported from Michigan or Ontario. The depth of water was about the same as for the Lockport, but on its south side the dam extended much farther east, probably to the hills south of Syracuse. At this stage of retreat a lobe of the glacier extended southeast from Georgian bay to, or nearly to, the Oak ridges 20 miles north of Toronto, and it seems probable that between this lobe and the northern limb of the Albion dam, which then filled the lower part of the Trent valley as well as the eastern half of the basin of lake Ontario, there was a lake covering the upper part of the Trent valley and probably part of lake Simcoe also, and having its outlet southward to the Ontario basin.

Such were the great ice-dams—immense ice-walls or barriers hundreds of miles long and standing for much of their length in water hundreds of feet deep. The foregoing description of the positons of the ice-dam where it crossed the present water-filled lake beds is, of course, in each case largely conjectural. But in most instances there is a fair basis of fact to guide one's estimate, and the waterlaid moraines which have been traced across some of the basins in their dry parts furnish invaluable precedents and principles. It is possible that in some cases the course of the submerged moraine across the lake bottom may be traceable by a study of the soundings. In the southern part of lake Huron there is a submerged ridge showing sand and clay and gravel. It is 200 to 300 feet below lake level and trends very closely in line with the Hagenville moraine produced towards the southeast and may in fact represent it. There are probably also rock ledges, however, having the same general trend and from which any supposed morainic ridges must be carefully distinguished.*

Solidity of the Ice-lobes.

The reality of ice-dams of such great magnitude might be doubted on the ground that the lobes of a glacier could not stand in water 200, 500 or 1,000 feet deep, because they would break up and float away as icebergs. Mr. Leverett suggests this view in both of his papers referred to above.† To the writer, however, it seems clear that such a conclusion is not warranted by the facts now at hand. If it be examined critically this assumption will be found to rest on a supposed similarity where in reality similarity does not exist. The great ice-streams that flow out from the main ice-sheet of Greenland through the deep fiords move at a relatively rapid rate and break off as icebergs as fast as they advance. No doubt the ice-lobes in our lake region would have done the same under the same conditions, but the conditions affecting them were very different. Our lobes were not narrow ice-tongues squeezing out through canyon-like fiords, but were broad lobate masses and moved forward with extreme slowness. Fiord tongues move so fast that great cracks and crevasses are produced in them dividing them into blocks which readily float away as soon as they enter deep water. Our lake lobes, on the other hand, moved so slowly that they must have remained essentially solid to their front edges, and so did not easily break up.* No doubt their fronts were undercut to some extent by the waves and pieces were sometimes broken off, but such breaks must have been rare and did not count as an important factor in ablation. In no case so far discovered was it effective enough to make the lobe front concave, as has been assumed by some authors for comparatively shallow waters in lake Agassiz and in the basin of lake Champlain.† In depths of 200 feet the solidity of the ice-lobes appears to be beyond question. For the continuous tracing of the Defiance, Saginaw, Port Huron and Detroit moraines, and the long northern limb of the Toledo moraine leaves no room for doubt. These moraines all show that the lobes which made them fitted themselves to the relief of the submerged land just as perfectly as if no water had been present. The facts show three things with respect to the condition of the ice in the lobes: it must have been hundreds of feet thick near the edge; it must have been essentially solid and without crevasses, and it must have moved at a relatively slow rate—very much slower than the motion of Alpine glaciers and Greenland fiord tongues.‡

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*See U. S. Lake Survey chart of lake Huron.

†Page 296 in the first; pages 14-15 in the second.

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*Recent photographs by Chamberlin, Salisbury and others showing the fronts and edges of tongues of the Greenland ice-sheet, where they terminate on land, may be taken as good illustrations of this condition. (See recent volumes of Jour. of Geol., and Bull. G. S. A.)

†Warren Upham in "Glacial Lake Agassiz." Monograph XXV, U. S. Geol. Survey, 1896; plates XVII, XIX and XX. S. P. Baldwin in the "Pleistocene History of the Champlain Valley." Am. Geol., vol. XIII, March 1894, p. 181. T. C. Chamberlin in James Geikie's "Great Ice Age." 1894. Plate XV, facing page 727.

‡Remembering that the specific gravity of ice in fresh water is .92, it is plain that a solid mass of ice having a superficial area of say one square mile or more and a thickness of 1100 feet would not quite

The Ice-dammed Lakes.

Lake Maumee. (First stage.) The lake which was held in front of the Defiance ice-dam has been called lake Maumee.* Its beaches were known to the earliest inhabitants, by whom they were chosen as roadways through the forests and were called "ridge roads." The one on the south side of the lake is known as the Van Wert ridge and runs westward from Findlay

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float free of the bottom in 1000 feet of water, and every foot added to its thickness would increase the pressure on the bottom and reduce the tendency to float. It can hardly be doubted that where the ice filled deep lake basins like that of lake Ontario, its thickness 30 or 40 miles back from the edge might have equaled or exceeded 1100 feet. Indeed, we can not avoid the conclusion that when the ice-front stood at Lockport on the moraine of that name, the thickness of the ice in the deepest part of the Ontario basin directly north of Lockport must have been at least 1100 to 1200 feet, else the glacial surface could not have sloped toward Lockport, which it certainly did. That point was then probably not over 30 or 40 miles back from the apex of the lobe in the west end of the basin as the lobe would have been with the water absent. As it was, the thinner edge of the ice probably broke off back to a point where its thickness was 1100 feet or more, though actual evidence of such a condition has not yet been reported. In this connection it is interesting to note the conditions of the great "icy barriers" of the Antarctic regions. The Antarctic ice-sheet appears to be a noble example of its kind and in most respects truly comparable to the great Pleistocene sheet that overspread so much of North America, except that its wastage is mainly in the sea by icebergs, while that of the older sheet was mainly on land by melting. The great Victoria barrier is a continuous ice-wall rising vertically from the water 100 to 200 feet, with few cracks or crevices and with flat and even top—the whole extending about 450 miles in length; and there are several others of similar character and proportions. The bergs that break off from these barriers are not numerous, but they are of gigantic size and of a tabular form not seen in Greenland. Prof. Wyville Thomson of the "Challenger" Expedition says: "The icebergs, when they are first dispersed, float in from 200 to 250 fathoms." (1200 to 1500 feet.) "I conceive that the upper surface of one of these great tabular southern icebergs, including by far the greater part of its bulk, * * * was formed by the piling up of successive layers of snow during the period, amounting perhaps to several centuries, during which the ice-cap was slowly forcing itself over the low land and out to sea over a long extent of gentle slope, until it reached a depth considerably above 200 fathoms, when the lower specific weight of the ice caused an upward strain which at length overcame the cohesion of the mass, and portions were rent off and floated away." (Quoted by Prof. Huxley in his "Discourses Biological and Geological." p. 80.) Probably this process became effective in the deepest parts of our glacial lakes, but the areas over 1000 feet deep were very limited, the deepest being about 1430 feet in lake Superior. The conditions of the icy barriers of the Antarctic regions, and not of the fiord tongues of Greenland, furnish a true parallel to the conditions of our ice-lobes, where they entered the deeper parts of our glacial lakes.

*So named by C. R. Dryer in "Geology of Allen County," in the sixteenth report of the State Geologist of Indiana, 1888, pp. 107-126.

through Delphos and Van Wert in Ohio, curving gently northward to New Haven, Ind., on the south bank of the Maumee river six miles east of Fort Wayne. The one on the north side runs at about the same level from Adrian, Mich., southwest through Bryan and Hicksville, O., to a point on the north bank of the Maumee about four miles east of Fort Wayne. This is known as the Hicksville ridge. More recently the two ridges have been designated by one name as the Maumee beach. *

East of Fort Wayne, where they are about one mile apart, on opposite sides of the Maumee, the two lines of the beach become parallel and pass into the head of a large abandoned river channel, which extends westward through the city and thence twenty-five miles southwest to Huntington on the Wabash river. The old channel averages about a mile wide and twenty to eighty feet deep in drift, but has only a very

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*The names "Van Wert ridge" and "Hicksville ridge" were in use locally at an early day, but implied nothing as to the nature or origin of the ridges. N. H. Winchell in his reports in the "Geology of Ohio," vol. II, adopted these names under the impression that the ridges were moraines. To designate them properly as a single beach line, which they are, it has seemed necessary to find a new name, and for this purpose the name "Maumee," which is the name of the lake itself, seems most appropriate. Mr. Gilbert designated the beaches of the north side of the Maumee valley as Nos. 1, 2, etc., the Hicksville ridge being No. 1.

Note to Fig. 2. Four sketch maps showing successive positions of the receding ice-front with accompanying lakes. Map I, Lake Maumee (first stage); Maumee beach, Defiance ice-dam and Fort Wayne outlet. Map II, Lake Maumee (second or two-outlet stage); Leipsic beach, Detroit-Euclid ice-dam and Fort Wayne and Imlay outlets. The beaded line shows the position of the Toledo-Newburg dam, which was passed without a change of outlet. Map III, Lakes Whittlesey and Saginaw; Belmore beach, Port Huron-Gowanda and Saginaw ice-dams and Ubly and Grand River outlets. Map IV, Lake Warren; Hagenville-Alden ice-dam, upper Forest or Crittenden beach and Grand River outlet. The Hagenville-Alden dam marks apparently the last position preceding the opening of Mackinac straits. The beaded line marks the approximate place of the ice-front at the time of the Albion dam, when the eastward outlet opened at Syracuse. The place of this line is largely conjectural, being based on four small and widely separated fragments, two of which are not certainly identified. But with the aid of the earlier and better known lines and a careful estimate of the influence of topography, the position indicated may be regarded as a fair approximation. Two other halting places of the dam might have been indicated on this map: the Lockport dam between the Hagenville-Alden and the Albion, and the Alcona-Hamburg next in front or south of the Hagenville-Alden. But neither of these unrepresented dams was critical; the upper Crittenden beach ends at Alden and only the lower extends beyond. Except in New York and western Ontario, the place of the Lockport dam is only a degree less conjectural than that of the Albion. The light broken lines east of Buffalo, north of Toronto and west of Hagenville represent known or probable extensions of the lower Forest or Crittenden beach at the time of the Albion dam.

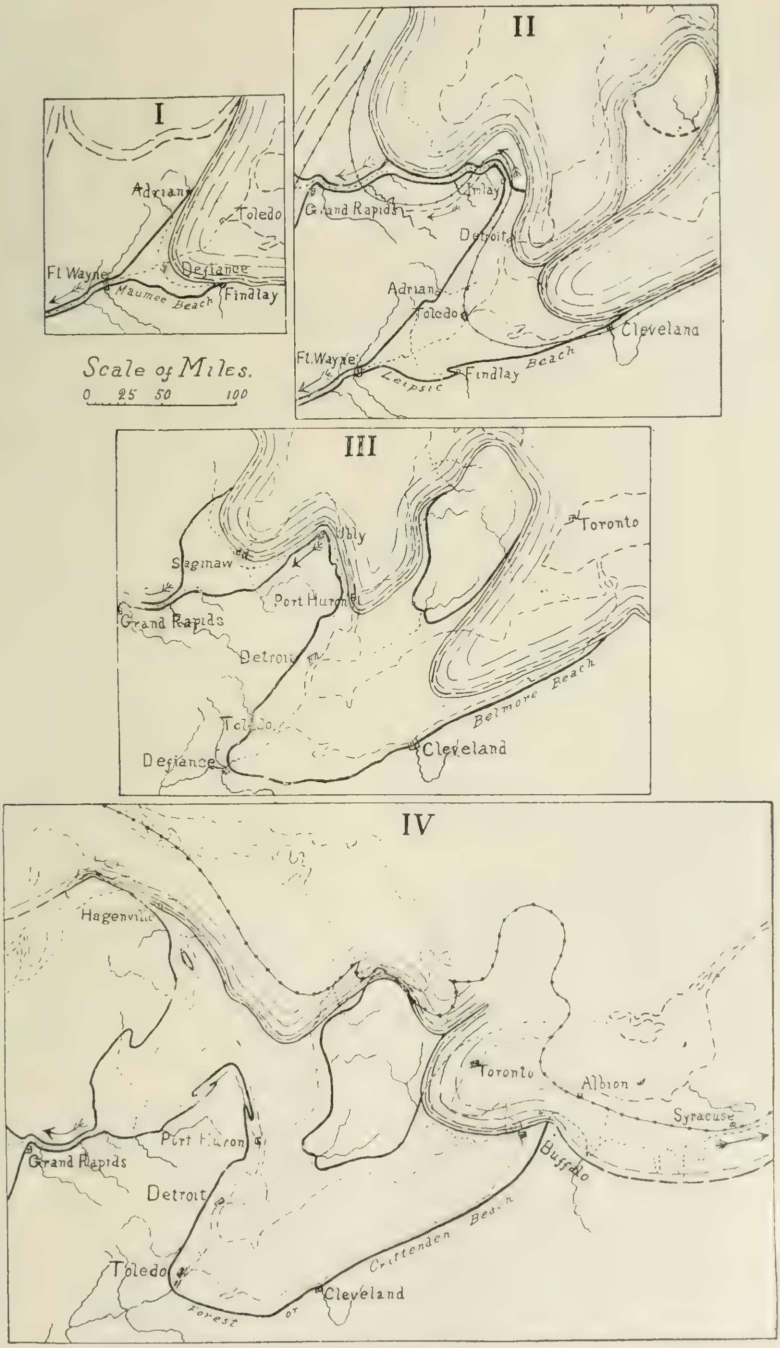
I
Adrian
Toledo
Ft Wayne
Defiance
Findlay
Maumee Beach
Scale of Miles.
0 25 50 100
II
Grand Rapids
Imlay
Detroit
Adrian
Toledo
Cleveland
Ft. Wayne
Leipsic
Findlay
Beach
III
Ubly
Toronto
Saginaw
Port Huron
Grand Rapids
Detroit
Toledo
Belmore Beach
Defiance
Cleveland
IV
Hagenvi
Toronto
Albion
Syracuse
Port Huron
Grand Rapids
Detroit
Buffalo
Crittenden Beach
Toledo
Forest or
Cleveland

Fig 2.

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slight westward declivity, except in the last three miles, where the descent is more rapid over a sill of limestone.

The boundaries of this first stage of lake Maumee are fully known, provided we suppose a continuous ice-wall along the Defiance moraine to have constituted a water-tight barrier on that side. The lake was shaped somewhat like a barbed arrowhead with the point at Fort Wayne and the barbs at Findlay and Adrian. It was about 40 miles wide east and west between Defiance and New Haven and 50 miles north and south through Defiance, while from the point to the barbs was about 75 miles each. All the boundaries of this first stage of lake Maumee are well shown on Mr. Gilbert's map referred to above. The Maumee beach is nearly level throughout and is on the average about 220 feet above lake Erie.

Mr. Leverett describes the beach in the following words:

"The Van Wert ridge so far as I have examined it consists in the main of a deposit of sandy gravel, though for considerable distances it presents only a wave-cut bench free from gravels. It is not a strong beach, its usual hight being 2-5 feet and its breadth but 10-12 rods. Occasionally, however, opposite where streams tributary to the lake had their debouchure, it is much larger, standing 12-15 feet above the plains on either side of it and having a breadth of 20-40 rods or even more."*

Lake Maumee. (Second or two-outlet stage.) As the ice-front retreated from the Defiance moraine, it uncovered new ground upon which the water advanced as fast as the ice receded. Theoretically, the waves must have begun immediately to make a new beach, which would appear as a faint extension of the Maumee beach, because made at the same level. Northeast from Adrian a long, tapering bay was gradually opened between the ice and the land just uncovered and this bay extended far up into Michigan to Imlay City west of Port Huron, where a new outlet was opened. The old channel of this outlet extends from near Imlay City north and northwest to a point a few miles beyond the village of North Branch and then turns to the southwest, passing down the valley of Flint river. This channel is quite narrow as compared with the other outlets of these waters, being only about one-third of a mile wide. It lies near the frontal base of the Toledo moraine, which curves to the north of it. It is not so close, however, as the channel in another case to be mentioned presently. The moraines here lie close together and the channel is about midway between them.

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*Am. Jour. Sci., April, 1892, pp. 286-287.

On the principles laid down in the opening pages of this paper, we should say that the water at the level of the first stage of lake Maumee must have extended nearly to Imlay City before the new outlet opened and the level of the lake fell. On the south side a similar extension must have taken place from Findlay towards Cleveland. The course of the Toledo moraine, however, shows that the northern 30 or 40 miles of the long bay must have been very narrow, mostly not over five miles wide, for this moraine runs nearly parallel with the great interlobate ridge on the west and close to its base; and the long arm may have been narrow on the south side of the lake also. The fact that Mr. Leverett did not find any representative of the Maumee beach east of Findlay, although he says he made particular search for it, and the fact that it has not been reported north of Adrian may be due mainly to these conditions. It seems probable, further, that the Imlay outlet opened before the ice-front had receded so far as Toledo, in which case there would be this additional reason for faintness on the part of the extended beach. Theoretically, however, the Maumee beach ought to be found extending in faint form some distance beyond both Findlay and Adrian.

The new outlet was neither low enough nor large enough to take the whole discharge of the lake, so that the Fort Wayne outlet continued to be active, but with reduced volume, and this apparently is the explanation of the smallness of the Imlay channel. But the opening of the new outlet lowered the level of the lake slightly, and a new beach began to be formed around its whole shore. This is called the Leipsic beach* and westward from Findlay is generally about ten feet below the Maumee, but on the north side Mr. Gilbert reports it about 25 feet below. It has been traced to the head of both outlet channels.*

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*From the Ohio-Michigan line north to the vicinity of Port Huron, the beaches were explored by Dr. J. W. Spencer. He called the highest one which he found the "Maumee beach," supposing it to be the same as Gilbert's highest in northwestern Ohio. He represents it as extending from Cleveland to Fort Wayne, thence northeast in Ohio and Michigan, through the Imlay outlet, across the Saginaw valley, through the Pewamo or Grand River channel and on past Chicago. (Am. Jour. Sci., vol. XLI, March, 1891; map.) Although the tracing is not yet complete, it now seems quite certain that Spen-

When the ice-dam retreated to the Detroit-Euclid line no new outlet was opened, so that the same two ways of discharge continued to serve. On the thumb in Michigan the ice-front did not draw back far and the newly uncovered ground was a trifle higher than the Imlay channel. To the north, however, the thumb slopes gently downward and its crest was in a re-entrant angle of the receding ice-sheet.

Referring to the Leipsic beach in Ohio, Mr. Leverett says: "The general appearance of this beach is much like that of the Van Wert, though it is on the whole somewhat stronger. Throughout much of its course it stands 6-8 feet above the plain north of it, and in places 15-20 feet."† This is precisely as would be expected, for this stage of the lake lasted during two halts of the receding dam.

Lakes Whittlesey and Saginaw. The two ice-dams which retained this lake stood on the Port Huron and Gowanda moraines. As soon as the ice began to withdraw from the Detroit moraine new points of overflow opened across the thumb farther north, but served only as temporary spillways. For the ice was retreating down hill and the place of overflow kept

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cer's "Maumee" in Michigan is the same as Gilbert's No. 2 and Winchell's Leipsic ridge in Ohio. This beach passes into the head of the Imlay channel west of Port Huron and ends there. The name "Maumee," which Spencer applied to Gilbert's beach No. 2, supposing that beach to be No. 1, is in fact now applied to No. 1, as noted above. Observations show that neither the Maumee nor the Leipsic beach extends to the Saginaw valley or to Chicago.

*Until recently, the connection of the Leipsic beach with the Fort Wayne outlet seemed to the writer improbable, for Mr. Gilbert reported it to be on the average about 25 feet below the Maumee, (Geology of Ohio, Vol. I, p. 552) at the same time giving the average depth of the head of the Fort Wayne outlet near New Haven, Ind., as only 20 feet. (p. 550). But Mr. Leverett recently called the writer's attention to the fact that on the south side of the valley, from Findlay westward about to the state line, which is as far as he had traced it, this breach averages only about ten feet below the Maumee, thus bringing it up high enough for the supposed connection and putting it in accord with the conditions indicated by the Imlay channel, which is certainly too narrow to have carried the whole discharge of the lake. This relation seems to indicate that there was also at the same time a considerable discharge through the Fort Wayne channel.

†Am. Jour. Sci., April, 1892, p. 293.

changing until finally, when the ice-front came to a stand on the Port Huron-Saginaw moraine, a permanent outlet was established close along the foot of the ice in the angle. The main head branch of this channel begins about two miles east of the village of Ubly and after running two miles northwest turns sharply in the angle of the moraine and passing close west of Ubly, extends thence 18 miles southwest to Cass City, where it entered lake Saginaw another glacial lake, which filled the Saginaw valley. This channel is about a mile wide and has drift banks 20 to 100 feet high. The beach of lake Whittlesey is called the Belmore beach and in Ohio, is about 160 feet above lake Erie, or something like 40 feet lower than the Leipsic.* "It is well defined as far as Sheridan, New York, and may possibly continue to Hamburg, though the beach is apparently less definite than west from Sheridan. From Hamburg eastward, so far as has yet been discovered, this beach has no continuation."† The Gowanda moraine probably crosses its level at Sheridan. The Leipsic beach, next higher, has not been found east of Euclid. A demonstration of its disappearance in that direction would agree with the fact observed in Michigan that the lake level began to fall soon after the ice commenced to retreat from the Detroit-Euclid moraine.

Lake Warren. When the ice withdrew from the Port Huron moraine, a wide passage around the end of the thumb was quickly opened; lake Whittlesey fell and blended with lake Saginaw, and the outlet of the latter lake through the Grand river channel became the outlet of lake Warren.

The Grand River channel is the most magnificent outlet directly associated with this series of lakes. It is a mile wide and 50 miles long and in some places it is more than 200 feet deep in drift. The beach of lake Warren is the Forest or Crittenden beach.‡ In Ohio and eastward it is compound in form, being made up of several beaches close together; on the thumb in Michigan it nearly always presents a dual form, one ridge being about ten feet above the other. Its ridges in Ohio cover the interval from about 90 feet down to 65 feet above lake Erie. On entering New York it begins to rise somewhat in altitude, and it changes in the same way northward on the thumb. At their first halt the ice-dams of lake Warren stood at the Alcona and Hamburg moraines. It seems certain that no change of lake level or outlet occurred until after the next halt, when the dams stood on the Hagenville and Alden moraines, for Mr. Leverett found the upper member of the Forest beach extending as far as Alden. The remainder of the history of lake Warren has not been worked out, except as to the location of two moraines in New York and the place of its eastward outlet at its closing stage. According to Prof. Fairchild, the lower member of the Forest beach has been traced from north of Indian Falls, N. Y., eastward along the north or inner side of the Lockport moraine to Lima.*

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*"Belmore" is the name used by Winchell, and designates the same beach as Gilbert's No. 3. This beach in Michigan is Spencer's "Ridgeway," and east of Cleveland into western New York it is Gilbert's "Sheridan." The tracing is not yet continuous for the whole length of the line, but the identifications seem to admit of no serious doubt.

†Mr. Leverett, in a letter in Am. Geol., vol. XXI, March, 1898, p. 197.

‡In southwestern Ontario, Dr. Spencer traced a beach which he called the "Forest," and he afterwards identified its counterpart in Michigan. (Am. Jour. Sci., vol. XLI, March, 1891.) Mr. Gilbert traced a breach from Cleveland into western New York, to which he

On the hills south of Syracuse are the magnificent abandoned canyons and waterfalls which were discovered three or four years ago by Mr. Gilbert. They were made by a great river flowing eastward and the head levels of the upper ones are suggestively near the level of the plane of the Forest beach produced. From the relations of the moraines and beaches it seems clear that these outlets could not have been open while the ice-front stood on the Lockport moraine. For Indian Falls and Batavia are towards the end of the lobe and Syracuse is far back on its side, so that the margin of the ice must have been higher at Syracuse than at Batavia. Hence it seems probable, as the only alternative, that the Albion ice-dam stood with its front resting on the hills south of Syracuse when the eastward outlet was first opened close along its foot, and that it was during its stand there and during the early steps of its retreat from that position that all those channel features were made.

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applied the name "Crittenden." It seems certain that the two are in reality the same beach. Latterly, Prof. Fairchild and others have sometimes designated this beach as the "Warren shoreline." Spencer originally applied the name "Lake Warren" to supposed extensive high level waters, whose existence, however, has not been establishd. The present more restrictd application of the name was suggested by the writer in 1896. (Bull. G. S. A., vol. 8, 1896, pp. 56-57.)

*Lake Warren Shorelines in Western New York and the Geneva Beach." Bull. G. S. A., vol. 8, 1896, plate 30.

In that event lake Warren must have continued to exist during the halts at the Lockport and Albion moraines, though at the time of the latter it was beginning to shift its outlet from west to east and soon fell away to a much lower level.

The correlative relations of these features with the moraines in Michigan seem to leave little doubt that during the time of the Lockport and Albion dams there was an open passage from the Huron to the Michigan basins through the straits of Mackinac. The writer has been of opinion heretofore that lake Warren never extended to the basins of lakes Michigan or Superior. That opinion was based on the fact that careful search for shore lines above the Algonquin beach at Petoskey, Mich., and near Indian river and Rogers City farther east on the same slope had yielded only negative results, although these localities were very favorably exposed. The ground at Petoskey was reviewed with special care in September, 1897, but without finding any evidence of a beach. At the same time, the writer had ventured to entertain some doubt as to whether Mr. Leverett's Gowanda and Alden moraines were really distinct members of the recessional series. It was thought that they might possibly be spurs or secondary ridges belonging to one of the other moraines near by—the Gowanda to the Dayton (Euclid) and the Alden to the Hamburg. While nothing has occurred to change the report of facts relating to the absence of high beaches at Petoskey and eastward through the straits, a careful reconsideration of Mr. Leverett's work on the moraines of New York suggests a contrary conclusion. It suggests that in its last stages lake Warren probably did extend westward through the straits, although not occupying their whole width. For, taken in connection with the clearly defined correlation of the moraines in the two branches of the diverging series, it seems plain that Mr. Leverett's positive evidence from the moraines of New York furnishes a safer ground of inference than the writer's negative evidence as to the extension of the Forest beach through the straits of Mackinac. Pending further research in the field, therefore, the conclusions suggested by Mr. Leverett's work should stand first. If lake Warren did in fact extend to the Michigan basin, then it blended with lake Chicago (the glacial lake of that basin) and the Chicago channel became for a time its outlet. A slight drop of the water level would have resulted and this may have been the cause of the dual form of the Forest or Crittenden beach.*

Mr. Warren Upham has contended strongly for the view that lake Warren covered the whole area of the four upper lakes. The course of the ice-front at the time of this lake as he represents it, however, passses from a point east of Buffalo, N. Y., presumably on the Lockport moraine, directly northward, east of Georgian bay and lake Nipisssing and far to the east of lake Superior.† But this hypothetical course is now known to be widely at variance with that indicated by the moraines. At the time of the Albion dam the ice must still have covered the whole of Georgian bay, and nearly half of lake Huron, the north side of the straits as they were then and probably more than half of lake Superior.

Without offering any proof that they really are so extended, Dr. J. W. Spencer has claimed an extension of all these glacial lake beaches, and others supposed to have been found at higher levels, over the whole lake region and on to an indefinite distance over the lower St. Lawrence valley. He also denies that the abandoned outlet channels associated with the beaches are old river courses. On his view all the beaches are of marine origin. As applied to the features of the region here considered, however, such a hypothesis falls far short of accounting for the facts in a satisfactory manner. For among the facts gathered from this region there are so many things which are clearly characteristic products of glacial agencies and as clearly impossible products of marine agencies that a mere statement of the facts ought to be a sufficient and conclusive answer. Some of the most important features to be accounted for demand for their explanation the supposition of a movable, water-tight barrier or dam retreating across the lake basin in a northerly direction. The relation of the beaches to the outlet channels plainly demands such a receding barrier.

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*If the straits were opened during the time of lake Warren this event probably occurred when the ice withdrew from the Hagenville moraine. Agreeably to this idea, Leverett found the upper Crittenden beach ending near Alden and Fairchild found only the lower member extending on to Lima. This suggests that lake Warren should be considered as having had two stages, falling from the upper to the lower when the ice-dam withdrew from the Hagenville-Alden moraine and opened the straits of Mackinac.

†Am. Jour. Sci., vol. XLIX, Jan. 1895. Boundary No. 4 on Plate I

If the moraines be supposed to mark successive halting places of that barrier it at once becomes apparent that their disposition in the basins is precisely such as is required to explain the beaches and outlet channels. It is hard to see how marine submergence can have any definable relation to features which have a demonstrable dependence upon a receding dam or barrier.

The Significance of the Ubly Channel.

One of the most significant and characteristic features found in the area of these lakes is the Ubly outlet channel. It is in some respects a truly remarkable thing. Its situation so far out towards the end of the thumb and the fact that it hugs the foot of the Port Huron-Saginaw moraine in its re-entrant angle presents a combination of facts favoring great ice-dams and glacial lakes perhaps as clearly and forcibly as anything that has ever been found.

The thumb of Michigan projects out into the open waters of lake Huron about 60 miles. Its crest, not counting the morainic hills which lie upon it, is a trifle over 200 feet above the lake and this altitude runs out to within 20 miles of its end. The head of the outlet channel is about 30 miles back from the point and 210 feet above the lake. The channel has a long summit swamp connected with its head and a gravel delta at its foot, and bowlders and gravel and sand bars show the direction of flow to have been from east to west. Thus, the thumb is almost a promontory and the channel crosses its back from east to west half way out towards its end. How can the existence of a great river channel in such a situation be explained? How is it related to the different explanations which have been suggested for the waters that made the old shore lines of this region?

Besides ice-dams, the only alternative explanations of the expanded waters of the Great Lake region are, (1) Marine submergence due to subsidence of the land, and (2) Lakes retained by land barriers due to tilting or unequal uplifts or subsidences of the land. If we adopt the marine hypothesis we must either ignore entirely all the old outlet channels or regard them merely as cols near sea level and more or less modified by tidal action. As has been pointed out by Mr. Leverett, some of the old channels are demonstrable products of river action, and were therefore connected with lake waters. He notes the fact that the Chicago outlet had rapids near Joliet, where a descent of 70 feet was made in only nine miles.* Several of the channels near Syracuse, N. Y., show the sites of abandoned waterfalls. It seems obvious that the shore lines which lead into the heads of such channels mark the boundaries of lake waters standing at some considerable hight above sea level, and not of gulfs or bays of the ocean. The fact that the Ubly and other channels show no well marked sites of rapids or waterfalls has no weight against the supposition that they too are products of river action. This is a mere accident of topography. Most of them show more or less of a delta deposit at one end, and gravel bars and bowlders in their course indicate the direction of flow. The Chicago and Syracuse channels are in the same series and drained the same basin as the Ubly and Imlay and Fort Wayne channels; but the former are at lower levels and were active at later times. If the waters were fresh when they flowed past Syracuse and Chicago what reason is there to suppose that they were marine when they stood at higher levels? The Grand River channel is 50 miles long and one mile wide. If its evidences of current action are due to ocean tides then the waters that connected with it must have had considerable tidal oscillation; but the beaches which enter it are plainly the product of waters that had very little if any tidal oscillation. These are some of the general reasons against a marine origin for the beaches and channels. For the Ubly channel in particular, the significant fact may be noted that the Belmore beach which connects with its head has no representative on the inner or north side of the Port Huron-Saginaw moraine, although that side at the level of the beach would have been openly exposed to heavy surf from over the basin of lake Huron if the ocean had stood at that level. Thus, the tidal or marine theory of the channels, including the Ubly, and of the beaches connected with them, must be discarded as untenable for both general and specific reasons.

For some of the channels of the lake region the idea of temporary lakes due to elevated land barriers is quite plausible.

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*Letter referred to above, p. 196.

For instance, a slight tilt of the lake region from east to west would shift the present outlet from Buffalo to Chicago, or a tilt from south to north would shift it to North Bay, Ont., and the Ottawa river. The outlet was actually shifted in this way from North Bay to its present course not many thousands of years ago.* But on account of its peculiar situation the Ubly channel cannot be explained by any admissible amount of tilting. The Saginaw and St. Clair valleys are branches of one wide valley and the Ubly channel crosses the outer end of a ridge which only partially separates them. There is no way to accomplish this by tilting the basin, except by tilting it in a manner entirely out of harmony with the observed attitude of the Belmore beach, and by an amount sufficient to raise the bottom of the south arm of lake Huron and the mouth of Saginaw bay higher than the head of the channel, without at the same time tilting the Erie basin farther south. But such a supposition implies an amount of differential upheaval for which the geological structure of the region not only furnishes no evidence, but positive disproof. If the channel were in hard rock the antiquity of its origin and the extent of subsequent changes might have obscured its cause. But it is in drift and is therefore of very recent geological date.

As it appears now, the channel begins in air and ends in air. Without a barrier to close the Erie basin it could have had no lands to drain, and without a similar barrier for the Saginaw valley it could not have stopped at Cass City, instead of flowing on as a river down to the valley bottom. Independently of the idea of the ice-sheet, the facts on the thumb point to the following conclusions. A barrier must have rested on the Port Huron-Saginaw moraine along the north side of the Ubly channel and that barrier or some other must at the same time have extended to the east and west so as to close the Erie basin on the one side and the Saginaw on the other, completely separating the two. Otherwise, the two basins would not have been turned into lakes and a great river could not have flowed from east to west between them.†

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*"Origin of the Gorge of the Whirlpool Rapids at Niagara." Bull. G. S. A., vol. 9, 1897.

†The great outlet channels near Syracuse, N. Y., are equally significant in their relation to and obvious dependence upon an ice-dam, and they are in some respects much more impressive objects to the

Conclusion.

If the moraines mark halting places of the barrier and are to be accounted for in a manner accordant with their observed relations to the beaches and outlet channels, then there is only one order for the making of the series. Generally speaking, the barrier must always have faced southward and covered the lands to the north, and not vice versa; for the beaches and outlets could not be explained by a contrary supposition. Neither can we suppose the moraines to have been made all at once, nor in successive order from north to south, nor irregularly. They must have been made in series from south to north, for no other supposition puts the barrier into proper relations to the beaches and outlets.

The relation of the several moraines in the order of their series to the topography indicates a barrier composed of material in some degree mobile and plastic and moving in a southerly direction from the lake basins, which it must have filled solidly, not only to altitudes somewhat higher than the correlated beaches and outlets, but up to the hight of the highest parts of the observed moraines. These conclusions might have been reached without any knowledge of the real composition of the barrier, for they are all clearly indicated by the close interrelations of the beaches, outlets and moraines independently of the Glacial theory. But with the Glacial theory and the verity of the continental ice-sheet firmly established on a basis of facts which have no dependence upon shore lines and outlets for their interpretation, an explanation is at hand so clear and comprehensive and introducing so high a degree of unity and harmony among the many facts relating to the temporary lakes of the Great Lake region that no tenable ground

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eye than the Ubly channel. In this case a glacial lobe retreated down a partly dissected highland slope or escarpment and finally opened an outlet along its front directly across ridges and valleys. The backs of the ridges were cut through by the river and deltas were built in the intervening valleys. Some of the ridges were cut several times at successively lower levels. The general surface slopes rapidly downward to the north, while the channels run from west to east. The situation is such that the front of the ice-sheet must be supposed to have stood just there beside the channels while they were being made. There appears to be no possible alternative explanation of their origin. (Gilbert, abstract in Bull. G. S. A., vol. 8, 1896. Fairchild, in Bull. G. S. A., vol. 10, 1898, with maps and photographic views. Quereau, an account of Jamesville Lake, N. Y., Bull. G. S. A., vol. 9, 1897.)

of doubt remains; the barrier was glacier ice, which, as one vast sheet, crept slowly forward from the north, impelled by gravity and its own semi-plastic quality to follow the lines of least resistance across the country. The moraines of recession were made by it and they mark halting places of its retreating front. Its solidity and great extent and thickness, as evidenced by the general import of a wide range of glacial phenomena, show it to have been fully capable of constituting the retaining dam or barrier of lakes of such magnitudes as those described above. The great ice-dams of lakes Maumee, Whittlesey and Warren far surpassed all modern examples in the grandeur of their proportions, and they were as effective while they endured as the land barriers which retain the Great Lakes of today. The study of the ice-dams and the lake remains associated with them is highly important in another way, for, with the reality of the dams established, many new and helpful lights are thrown upon the character, conditions and behavior of the ice-sheet itself.

Until two or three years ago, the opponents of the theory of ice-dams had the satisfaction of seeing its advocates suffer apparent failure in every attempt to locate definitely and on actual evidence the place of the supposed dams. Mr. Gilbert, believing that he had traced the Iroquois beach to its end near Adams Center, N. Y., supposed an ice-dam to have rested at that place. Mr. Leverett, having traced the Leipsic beach to an apparent end in the city of Cleveland, concluded that an ice-dam had stood there on the Newburg moraine. In western New York, Mr. Leverett thought that the Crittenden or Forest beach ended near Indian Falls and was correlated with an ice-dam which stood on the Lockport moraine. Subsequently, however, Spencer and Gilbert traced the Iroquois beach beyond Adams Center; Upham traced the Leipsic beach beyond the Newburg moraine at Cleveland and Fairchild followed the Crittenden beach to Lima, N. Y., east of the Genessee river.

In a recent paper, Dr. Spencer claims in effect that these later extensions of the beaches beyond the supposed places of the dams are damaging failures amounting almost to disproof of the ice-dam theory.* But even as the facts stood then, logical thinking could hardly carry unfavorable inference so far. For, as Mr. Leverett pointed out in a recent letter,* the presence of the dams at the supposed places was not only not disproved by the later beach extensions, but the fact that those extensions are all much weaker and fainter than the previously known parts of the same beaches is, in reality, favorable to the supposition of ice-dams. Otherwise, why should the beaches change their strength and character where they cross or intersect moraines? The thing that the advocates of ice-dams had apparently failed to do was to find a dam so situated that its withdrawal would cause the lake to fall to a lower level—they had not certainly located a dam that was critical in the lake history. This is logically the most that Dr. Spencer could have claimed. In this connection it should be remembered, however, that it was not until 1896 that the outlet channels in southeastern Michigan were recognized and correlated with the beaches and moraines of the Erie basin. In the Ohio-New York area, Mr. Leverett found no outlet channels to guide him in his correlations. It was the finding of the channels in Michigan that brought out clearly the relations between the dams and the beaches, as the writer has endeavored to show more fully than before in this paper. We have seen above how the faint extensions came to be made and why it could hardly be expected that they could be traced to a clear connection with those moraines that mark the place of critical dams.

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*"An Account of the Researches Relating to the Great Lakes." Am. Geol., vol. XXI, Feb. 1898. pp. 116-117.

In a letter in reply to Mr. Leverett, Dr. Spencer maintains, further, that gravel floored channels across divides are not "evidence per se of glacial dams."† No one would claim that they are, except in regions that are known to have been glaciated; and even there the channels alone can not be regarded as full and final proof, but merely as strong evidence. If, however, such channels are found connected with shore lines in hydrographic basins favorably situated the presumption for ice-dams becomes all but conclusive. In such cases the theory of ice-dams is a more likely guide to a true interpretation than any other and ought not to be discarded until it is clearly disproved. Dr. Spencer appeals to a channel across the isthmus of Tehuantepec in Mexico and to certain high terraces in the Adirondacks and the mountains of New England as being phenomena identical in kind and due to the same causes as the channels and terraces of the lake region. But such arguments involve obvious fallacies. For the high terraces of the Adirondacks and New England are not like the beaches of the lake region—they are certainly not wave made, but are apparently stream made, probably by border drainage along the edge of the ice—and it is hard to consider seriously the suggestion that the col channels of our glaciated area were necessarily measured and cut on the pattern of more or less similar channels in the tropics, and under conditions controlled by identical forces. The answer to all such suggestions is that, as facts now stand, the evidence which has been gathered within the Erie-Huron-Ontario area itself is essentially complete and conclusive—not, of course, in all minute details, but in all those larger facts which are required for general interpretation. So it really makes no difference what is found in the Adirondacks or New England or in Mexico; facts from those regions can have no real bearing or weight as against the complete solidarity of the case which has been made out for ice-dams within the Great Lake area itself.

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*Am. Geol., vol. XXI, March, 1898, pp. 195-199.

†Am. Geol., vol. XXI, June, 1898. pp. 393-396. See also "Channels over Divides not Evidence per se of Glacial Lakes." Bull. G. S. A., vol. 8, 1891, p. 491.

ORIGIN AND AGE OF CERTAIN GOLD "POCKET" DEPOSITS IN NORTHERN CALIFORNIA.

By O. H. **Hershey**, Freeport, Ill.

The north central portion of Trinity county, in the heart of the Klamath system of mountains in northwestern California, is occupied by a nucleal series of bare granite peaks, the loftiest portion of the so-called Coast range of the state. Roughly stated, they form a dissected plateau with an average altitude of say 5,000 feet, that of individual peaks being over 7,000 feet the highest of all, Mt. Thompson, reaching about 9,125 feet, above the sea. That portion of the group which lies west of Trinity Centre and Minersville, is abruptly terminated on the eastern and southern sides, and the culminating point, Granite peak, over 8,000 feet in altitude, overlooks a broad basin made up of ridges rising to 3,500 and 3,700 feet, separated by narrow river valleys whose floors have an average altitude between 2,000 and 2,500 feet. On the eastern side is the main Trinity range, forming the watershed between the Klamath and Sacramento river systems, and reaching altitudes of 4,000 and 5,000 feet. It is this region of lower mountains, crooked river valleys and deep gulches, lying east of the White Granite peaks, that is preëminently the "pocket" country of Trinity county.

The geologic structure of these mountains is remarkably simple. There is a basement rock series of igneous or ancient quasi-volcanic material. Its prevailing characters on outcrop in the area under discussion are those of a compact, fine-grained, dull green massive rock closely resembling certain varieties of diabase. When exposed it has a ragged appearance because of extensive jointing, but it lacks the stratification lines of slate. Near the surface it is very frequently amygdaloidal, the original rounded cavities being now filled with white quartz. Several hundred feet below the top of the formation it becomes coarser grained, and finally passes into a coarsely crystalline rock of gray color, and an appearance like dioryte. The thickness is unknown but is at least 1,000 feet as that amount is exposed without any other appearing under it. In age it is probably Jurassic.

Resting upon the igneous formation is a series of alternating thin-bedded black slates and thick-bedded blue quartzyte, which collectively constitute the Black Slate formation, also of probable Jurassic age. In general, the slate formation remains practically in its original horizontal position except that it is gently arched with an axis along the summit of the Trinity range; but, considered in detail, it is much disturbed by faults and irregular folds of small dimensions so that locally it presents dips of high degree, in not a few cases vertical and even overturned. The igneous formation has participated in these disturbances to a certain extent so that the contact between the two varies as much as 600 or 1,000 feet in altitude between the two sides of a narrow ridge. In the valley of the Trinity river, the contact line averages several hundred feet above the stream level between Trinity Centre and Eastman gulch, but in places rises to 700 or 1,000 feet and in others the black slates come down to the river level. But, disregarding the local variations, it may be said that the green igneous rock forms the foundation of the entire region, outcropping in the valleys, passing through under the mountains to reappear in a distant valley or gulch. The black slates form the bulk of the mountains, capping every ridge and always above the green rock. The valleys are merely gigantic ditches cut by nature through the black slates and into the green rock below.

The contact plane between the massive green igneous formation and the black slates has so far proven to be the "pocket" horizon of the territory. Some gold in quartz ledges of low grade has been found in the diabase formation and perhaps a little may be scattered through the black slates above, but all the "rich strikes" have been made at or in the immediate vicinity of the contact. By reason of a long period of weathering in some ancient time, the green rock near the contact with the black slates has been softened and semi-decomposed and changed to a dull brown in color. It is popularly known as porphyry, but is as far from being a true porphyry as it can well be. Immediately above the contact, the black slate frequently has a shining lustre, a coal black color and a schistose structure quite unlike its usual characters. Sometimes there is a thin vein of quartz between the so-called porphyry and the black, slaty material, but generally they are separated merely by a thin seam of ferruginous dirt or by nothing at all. The dirt seam often carries a little free gold, but the "pockets" are found near or where seams of quartz penetrate the "porphyry" downward from the contact. The gold lies in a thin, flat sheet upon the igneous rock and under the slate, and in some cases extends a short distance into the former formation, rarely into the latter. It is in the form of coarse and fine grains, rarely threads, and sometimes nuggets of considerable size. The particles have a peculiar smooth and rounded surface, quite unlike the free gold in quartz veins. Indeed, so characteristic are the pocket "colors," that an experienced California miner can readily distinguish an isolated particle of "pocket" gold from both "river" gold and "quartz" gold.

The limited nature of this paper will not permit me to discuss the various theories that have been advanced in explanation of these curious "pocket" deposits, and I shall be obliged to content myself with a mere statement of what I conceive to be the correct theory of the mode of their formation. No miner has ever advanced it, and, so far as I know, I have an exclusive monopoly of its present conception. The very unusual nature of it will give it more than mere local interest.

After the Carboniferous period, the site of Trinity county was a land area for a sufficiently long time to cause a profound denudation of the three ancient rock systems of that area—the serpentine and white quartzyte formation, the schist formation, and the schistose clay slate formation—and then great fissures were opened somewhere and melted lava flowed out upon the land surface, overspreading a broad area in a thick sheet, and solidifying to form the most interesting formation of the entire country, the green diabase. Gold, probably in chemical combination with other elements, was an original constituent of this sheet of diabase, and to-day, according to a prominent assayer of Redding, Cal., occurs universally disseminated through it, (largely in combination with chlorine), not infrequently portions of the diabase assaying at the rate of $2.00 to $3.00 per ton of rock. That this great green massif is the source of practically all the gold in the black slate area of eastern Trinity county and western Shasta county, I have gathered, during practical prospecting work, overwhelming evidence of, which I cannot detail here.

Half a dozen distinct vein systems cut the diabase, yet only one contains gold in a concentrated condition. This is why the greater portion of the area of the diabase country is barren of paying mines. A certain particular set of conditions had to be fulfilled to gather the disseminated gold and concentrate it into the quartz veins. Some of these rich veins are lens-shaped, being completely surrounded by solid, unfissured country-rock. Indeed, small nuggets of gold have been found in the amygdaloids of the upper portion of the formation. In these cases, no idea can be entertained that the gold came from a great depth. It was taken into solution in neighboring portions of the diabase, by water slowly moving through the minute pores, and deposited along with the quartz in the amygdaloid cavities.

The surface of the diabase was subjected for a considerable period to subaërial denudation. The decay of the rock freed the gold which, being heavy and practically indestructible, remained in the soil of the land surface, gradually accumulating, becoming especially abundant where some rich quartz vein was being eroded. While the evidence collected in the field indicates some denudation, it does not prove a very long erosion interval at this horizon, yet considerable gold must have accumulated in the thin soil over the ancient lava plain.

Now the land went down beneath the sea, and the immense mass of Jurassic black slates was deposited over the green diabase. As each portion of the land surface successively formed the shore-line, the waves swept away the soil, laying bare the solid rock in places, but in others leaving a thin coating of the ferruginous clay. This, together with its golden contents, was especially protected from marine erosion in shallow depressions such as those in which the "pockets" are now generally found. Indeed, one who has studied the concentrating power of the waves, as I have on the gold-bearing beach of the peninsula of Azuero, Rep. of Col., would readily comprehend the probability of the ancient sea having swept the gold from broad areas of the sinking land surface, and concentrated it into certain very limited depressions, yet even there almost removing all of the lighter clay and sand. In this way would be produced the deposits as they now actually occur, namely, as a heterogeneous agglomeration of gold grains and what appears to be land-surface debris.

Old miners to whose consideration I have presented this hypothesis, have reminded me that the gold in the "pockets" averages decidedly coarser than that of the quartz veins and amygdaloids. At first thought this might prove fatal to the theory, but does not. The gold has probably been changed from its original very fine condition in one, or perhaps both, of two ways, as follows:

(1) It may have been dissolved by surface waters and redeposited in practically the same place. Whether this ever occurs, as, for instance, in alluvial gravels, is a mooted question at present. California contains some evidence on the subject, which I cannot discuss now. However it may be, I do not think that to any great extent this theory is applicable to the "pocket" deposits.

(2) The miners say the gold has been melted. Certainly, the condition of many of the pockets favors the idea that since

the concentration of the debris into the small depressions in the surface of the diabase, it has been subjected to great heat, many of the grains of gold having combined into larger particles and perhaps sometimes even a great many of them being thoroughly liquified and run together into large nuggets. This abnormal heating may have been locally produced by friction through movement of the rock on either side of the contact, of which there is evidence. Wherever the black slates are cut by dykes of "birdseye" porphyry, they have lost their dull color and regular lamination for a space of 10 to 50 feet from the dyke walls, and been converted into a peculiar schistose slate of a very bright shining lustre. Evidently heat caused this metamorphosis. Precisely similar schistose bands are found in places immediately above the contact with the diabase, especially where the strata show greatest disturbance from the mountain-building forces; and it is in these districts that the pockets of coarse gold are found.

Many of the gold-bearing quartz veins of northern California are of later age than has been postulated for the "pocket" deposits. The main gold-depositing period occurred after the Jurassic black slates were completed, probably during the time of orographic disturbance when the sea bottom was thrust up into a mountainous land area, and in great fissures rose successively the melted rock to form the dykes and magmas of greenstone, dioryte, "birdseye" porphyry and granite which are so characteristic of Trinity county. During this period the "pocket" deposits, being buried deep in the strata, must have suffered great changes, but the original concentration of the gold, if I have read the evidence aright, dates from an earlier period, the early Jurassic, and so far as known, they are in all probability the oldest workable gold deposits of the state of California.

May, 24, 1899.

GEOLOGIC NOTES ON THE WICHITA MOUNTAINS, OKLAHOMA, AND THE ARBUCKLE HILLS, INDIAN TERRITORY,*

By T. Wayland Vaughan, Washington, D. C.

Containing a Report Upon Igneous Rocks, by Dr. A. C. Spencer.

The notes here published were accumulated during a reconnoissance, made in the fall of 1896, under instructions received from Mr. Robert T. Hill.

The Wichita Mountains.

Probably there is no other area in the United States of so much geologic interest that has been less studied than the Wichita mountains. The first explorations were made in connection with Marcy's Red River expedition. Both Capt. Marcy and Dr. G. G. Shumard published general descriptions of the mountains in their itinerary, and Prof. Edward Hitchcock furnished for the report some notes on the rocks collected. The following description† of the mountains may be quoted with propriety:

> Thus far about twelve of the Wichita mountains have been examined, and have been found to present nearly uniform appearance and structure. Composed of fine granite of various degrees of hardness and color, they rise abruptly from a smooth and nearly level plain to the height of eight or nine hundred feet. Many of them are isolated and of an irregular conical shape, while others are grouped together in small clusters, and are more or less rounded. At a distance they appeared to be smooth, but upon a nearer approach their surfaces were found to be quite rough, and presenting the appearancec of loose rocks thrown confusedly together. In many places the granite was observed occupying its original position, and was variously traversed by joints and master-joints, which, intersecting each other at right angles, gave to the mass somewhat of a cuboidal structure. Soil rich, and from three to four feet thick; sub-soil argillaceous and of a red color.

Areas of "basalt," "greenstone" and "porphyry" are noted, also the occurrence of quartz veins. On page 146 of the report Prof. Hitchcock mentions "a great predominance of feldspar, and the almost total absence of mica" in the granite.

Dr. T. B. Comstock made a brief reconnoissance of the Wichita mountains in connection with his work on the Texas geological survey and published a report in the first (second) annual report of that institution, pp. 319-328. This contribution gives us much data on the geography of the mountain range, additional notes on the rocks constituting it, and Silurian fossils were found in the limestone hills on both sides of the plutonic axis. No positive evidence further than the Silurian strata are much tilted and the Permian slightly tilted, is presented bearing upon the time of the orogenic movements.

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*Published by permission of the Director of the U. S. Geological Survey.

†Marcy's Exploration of Red River, p. 163, 1854.

The last contribution is by Mr. R. T. Hill.* He gives some notes on the general topographic features of the mountains, and their constituent rocks. He states:

> The composition of the Wichitas is unlike that of any area of the southwest, and, so far as I could see, presents no structural resemblance either to the basin-surrounded mountains of the Trans-Pecos, or the early Paleozoic buttes and denuded folds of the Central Texas region. Their age is not determined. They are certainly post-Silurian and the Red beds have in part participated in the movements but the eruptives may be post-Cretaceous or even later. The apparent absence of the Lower and Upper Cretaceous in the composition of the Wichitas is especially noticeable."

General Topographic Features.

As one goes southward from Arapaho, he sees several mountain masses, thirty or forty miles distant projecting above the horizon line. As the mountains are approached, it is seen that north of the mountains there are rounded hills and that north of these hills there is a southward facing escarpment a hundred feet or more in hight. As my reconnoissance was mostly on the north side of the mountains, I can say but little, that is based on personal observation, concerning the south side. The main axis of the mountains trends slightly north of west, running from about Ft. Sill in the Comanche and Kiowa reservation a little north of Mangum in Greer county. They are about 120 miles long. Varying in distance from two or three to five or six miles north of the axis, and separated from it by a level, flat, grass-covered valley, are hog-backs of limestone, rising several hundred feet above the valley. Ten miles or more north of these hills, and separated from them by a valley is a southward facing escarpment, above which is the

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*"Notes on a Reconnoissance of the Ouachita Mountain System in Indian Territory", (Amer. Jour. Sci, vol. XLII, Aug. 1891, pp. 122-123) contain a brief description of the Wichita mountains.

Red Beds (Permian) prairie that stretches, except where interrupted by the drainage coürses, far northward into Kansas. There are some limestone hills on the south side.* South of these the country slopes to Red river, which is some thirty miles away.

The Axis.

Consists of a large number of isolated peaks or groups of peaks, that are separated by very level grass-covered meadows, scattered over which are solitary mesquite trees. These meadows are usually several miles across. When I saw them the grass was dead and dried up, and they are so level that the peaks seemed to be islands, rising with jagged, precipitous sides, above a straw colored ocean. The separate peaks or groups of peaks have all received names. Mr. Comstock in his report published by the Texas geological survey and already quoted, has given a sketch map showing the approximate location of many of the mountains, and has proposed names for others.

The following locations of the more important mountains were furnished by Mr. A. E. Williams, a surveyor from Oakdale, Oklahoma.

Iron Mt. sec 7, T. 4 N., on Range line between 16 and 17 W.

Little Bow Mt., in S. W. portion of T. 5 N., R. 18.

Elk Mt., in the same T. and R. as Little Bow, about three miles further north and on the west side of Elk creek.

Tepee Creek Mt., in southern half about the center of T. 5 N., R. 20 W.

Soldier's Spring Mt., in S. E. corner of T. 5 N., R. 20 W.

Devil's Canyon Mt., in T. 5 N., R. 20 W., on north side of the North fork of Red river.

Suttle's Mt., on the south side of the North fork of Red river opposite Devil's Canyon Mt.

Rainy Mt., in T 6 N., R. 16 W.

Twin Mts., in T. 3 N., R. 18 W., northern part of the township.

Round Mt., a small mountain in the S. W. ¼ sec. 18, T. 4 N., R. 17 W.

Tymatee Mt. in T. 5 N., R. 15 W.

Mt. Sheridan on line between T. 3 and 4 N., R. 13 W.

Saddle Mt., T. 5 N., R. 14 W.

Mt. Scott, sec. 36, T. 3 N. R. 12 W.

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*Comstock, First (2nd) Ann. Rep. Geol. Surv. Tex., p. 323.

Report upon the Rocks of Wichita Mountains

BY A. C. SPENCER.

The rocks of the Wichita mountains which were submitted to me for examination have been determined as follows:

Granites: Nos. 1, 9, 7, 15, are hornblende granites.

No. 1, near Johnson's shaft, Hornblende granite, is a perfectly granular rock composed of quartz, orthoclase, hornblende and mica, with apatite and magnetite as accessory minerals.

No. 7. Soldier's Spring Mt.—Granite porphyry. Large crystals of quartz and red feldspar imbedded in a holo-crystalline matrix of the same minerals. There is a small amount of green pleochroic hornblende in the section. The borders of the feldspar phenocrysts frequently consist of intergrown quartz and feldspar.

No. 15, western foot of Tymatee Mt.—Granite, is similar to No. 7 in its mineral composition but is not porphyritic. The feldspar and quartz are frequently intergrown.

Quartz porphyries. The two specimens of quartz porphyry, No. 17, southeast of Mt. Scott, and No. 18, [3 miles east of Hennepin, I. T.,] are dense red rocks composed of orthoclase and quartz laid in a ground-mass of quartz and feldspar with a hypocrystalline or micropoicilitic structure. The red color of these rocks is due to disseminated oxide of iron in the feldspar.

The remainder of the rocks belong to the gabbro family; they comprise typical gabbro, hypersthene gabbro, troctolyte, and anorthosyte. Gabbro—Nos. 11, 5, 16.

No. 11, Soldier's Spring Mt.—Gabbro, ophitic structure, is from a narrow dike in the granite. Its structure is different from that of the other rocks being quite plainly ophitic, otherwise it is similar to the other gabbros. It consists of basic labradorite and pyroxene with a large amount of ilmenite. Apatite is also present.

No. 5, S. side of quartz vein. Johnson's prospect shaft. Typical gabbro. This rock has been considerably altered but its original composition may be still made out. Basic labradorite and pyroxene are the essential constituents. The former has very few inclusions by which feature it is different from the feldspars of the rocks to be described. The feldspar and pyroxene are intergrown so that unoriented crystals of the former are set in large patches of the latter. This poicilitic structure may be plainly recognized in hand specimens.

Accessory minerals are ilmenite and apatite in small amounts. This specimen was collected from the walls of a quartz vein and the section studied is threaded by minute stringers of that mineral.

No. 16, Sec. 13, T. 4 N., R. 17 W., Middle Otter creek. Gabbro. This rock differs from No. 5 only in containing a very much larger percentage of ilmenite.

No. 2, dike in granite near Johnson's shaft, and No. 6, Iron mountain.—Troctolyte. These rocks are composed essentially of the same basic feldspar already described with a large amount of olivine. In

No. 2 there is besides, a small amount of pyroxene but ilmenite is present in small amount. In No. 6 there is practically no pyroxene and a large amount of the iron mineral. The feldspars of the two specimens differ in the size of the individual crystals, but appear to be identical in composition. In both rocks they are crowded with inclusions.

Near No. 6, Iron mountain, there is a mass of magnetite which has been exploited by prospectors and which is claimed to contain silver in appreciable amounts. If, as seems likely, this deposit of magnetite or ilmenite has been of igneous origin, the presence of silver in the parent magma and its concentration with the iron oxide is worthy of more careful study.

Anorthosyte. Nos. 14, 13, 4, and 8.

No. 14, About 2½ miles east of Johnson's shaft.
No. 13, About 2½ miles east of Johnson's shaft.
No. 4, Head of Otter Creek, N. side of Otter Creek Mt.
No. 8, Knoll about 3 miles north of Twin Mt.

These rocks are made up almost entirely of feldspar of the same basic labradorite composition which has been found to characterize the gabbro rocks of the Witchita region. The relation of the feldspar rocks to those which carry appreciable amounts of ferro-magnesian minerals is, however, shown by the occurrence in some instances of small grains of pyroxene. In every case the feldspars are crowded with inclusions of needle-like and tabular form.

Throughout the gabbro series the feldspars are twinned according to both the albite and orthoclase laws and in some cases the pericline twinning is present at the same time. The presence of the two laws first mentioned has made the determination of this mineral easy. The extinctions indicate a labradorite of basic composition. Furthermore the mineral is strongly attacked by hydrochloric acid.

Hypersthene gabbro. No. 12, West side of creek just north of Mt. Sheridan.

This specimen was collected at some distance from the other gabbro rocks. It differs from the typical gabbros in its structure and in character of its pyroxene. The relative amount of ferro-magnesian minerals and of feldspar is about equal. The pyroxene is mostly monoclinic but a part is orthorhombic and slightly pleochroic. Both pyroxenes are full of inclusions. The feldspar is similar to that of the other gabbros but its inclusions are somewhat different.

The remarkable variety of these related rocks is of extreme interest and they deserve careful study in the field.

The gabbro in some instances was found in dikes, cutting the granite. Specimens of rock, apparently decomposed rhyolitic tuff were found at several places. The quartz porphyry forms rounded hills near Ft. Sill, and to these Mr. Comstock gave the name Carleton mountains. The rounded topography of the quartz porphyry hills is very different from that of the jagged granite mountains.

The Sedimentary Rocks.

Ordovician.—On the north side of the plutonic axis of the mountains are hogbacks of limestone dipping with a steep angle to the north. One of these hills northeast of Tymatee mountain was composed of about 340 feet of hard blue oölitic limestone, sometimes arenaceous and containing large quantities of flint both in the form of sheets and nodules. The following fossils were collected at this locality:*

Rhaphistoma sp.

Ophileta complanata, var. nana.

The data are scanty and inexact. The fauna represented is certainly Ordovician and may be Calciferous.

One mile southeast of Fort Sill there is a quarry in a sandy argillaceous flaggy limestone. The following fossils were obtained at this locality: Paleophycus sp., Murchisonia sp., Cyrtoceras sp., Lingulella (?) cf. L. lamborni, Asaphas (?) sp.

These beds can be referred to the Ordovician, and may be as late as the Trenton. The relations to the Carboniferous are doubtful.

According to the reports of Hill and Comstock there are Lower Silurian hills on the south side as well as on the north side of the axis of the mountains.

According to Lieut. Savill of Ft. Sill, the Rainy Creek mountain is also composed of limestone. I did not go to this mountain, but from a distance it seemed to be composed of rock, apparently limestone, stratified in thick ledges.

The hill two miles west of Mountain City is composed of arenaceous limestone dipping about two degrees north. I collected in this limestone poorly preserved casts of Modiomorpha or Modiolopsis. The specimens are too poor for determination, and we cannot ascertain the age of this limestone more definitely than that it is Paleozoic.

Permian: The southward facing escarpment north of the valley on the north side of the Wichita mountains is composed of red beds that are Permian. The Permian is also exposed on the south side of the north fork of Red river in the vicinity of Suttle mountain. Here the base of this formation is composed of an arkose evidently derived from the disintegration of the granite hills. The material composing this arkose has been subjected to so little movement that it has not lost its angular character.

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*All of the paleontologic determinations are by Dr. G. H. Girty.

Section—Bluff North Fork of Red River, east side of Suttle's Mountain.

3.	Yellow river-sand composing top of bluff (second bottom)	4 feet.
2.	White arkose	4 feet.
1.	Vermilion clay and arkose	10 feet.
	River bottom of sand and clay down to level of water in river	10 feet

The flats intervening between the separate mountain peaks or the groups of mountains are underlain by deposits that are somewhat problematic. They have been denominated by Cummins the Fort Sill series.* Comstock was inclined to consider the formation Tertiary. He does not give any reason for this opinion. The material composing this Fort Sill series resembles in its lithologic character the Permian itself, composed of reddish argillaceous material, and extends from northward of the mountains toward the southward facing escarpment already mentioned. On the north side of Rainy Mountain creek, 15 miles southwest of Mountain City, the following section was observed that seems to belong to the same class of beds as those lying between the mountains.

3.	Red clay	5 feet.
2.	White clay, some sand	4 feet.
1.	Argillaceous limestone.	

This formation is still problematic and we probably shall not be able to ascertain its relations until the area has been the subject of detailed investigation.

The following section of Permian is made east of Fort Sill going toward Duncan. Section begins with No. 1, the lowest bed exposed.

5.	Red sandy clay	130 feet.
4.	Stiff blue clay, blotched with deep wine red	20 feet.
3.	Clays blue or yellow, sometimes blotched red on spurs in lower part of the bed, yellow in the upper	120 feet
2.	Shaly gray sandstone forming cap of hill on top of divide (dip variable northeastward or northward) This sandstone forms a compact yellow sandy soil. The	40 feet.

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*First Ann. Rep. Geol. Surv. Texas, 1890, p. 322, Austin.

country is an open prairie. Among the commonest plants are the bunch grass (Andropagon) and the weed known to botanists as Ambrosia. All the plants are small.

1. Indurated calcareous clay layers .... 4 feet

Total .... 314 feet.

One mile west and half a mile north of Duncan are exposures of white clays oxidizing very deep red. The clays of the same character are exposed in and around Duncan.

The general structure of the mountains has already been indicated; that is, a plutonic axis flanked on each side by foothills (hogbacks) of Ordovician limestone dipping away from it at a steep angle. On the north side beyond this the Red Beds dip away from the mountains at gentle angles.

Regarding the probable age of these mountains we possess as yet but little positive data. The granites are probably the oldest of the igneous rocks. The relations existing between the granite and the Lower Silurian limestone has not been determined. That the granites, however, are much older than the Permian is attested by the fact that before the deposition of the Permian beds the granites had been stripped of the sediments into which they were intruded, so that it seems quite probable that this granitic axis may be old Paleozoic. Preceding the close of the Permian and after the Silurian there was a period of orogenic movement by which the Silurian strata were much folded. Since Permian times the region has been subjected to but little orogenic movement. That there has been some, however, is attested by the gentle dip of the Permian strata away from the mountain axis or nucleus.

ARBUCKLE HILLS.

The Arbuckle hills are situated in the Chickasaw Nation, extending almost as far west as the Chicago, Rock Island, and Pacific railway. They are directly continuous on the east with the mountains of the Choctaw Nation and these with those of Arkansas.

Mr. Hill has already called attention to their topographic character. He says:

> "An elongated mass of low rounded barren limestone folds stands about 500 feet above the plain and extends east and west between

Wild Horse creek and the Washita river for about forty miles, forming an almost impassable barrier for wagon travel.*"

The Arbuckle hills are not jagged precipitous mountains like the Wichitas but are gently rounded hills. Looking south from Arbuckle, it can be seen that the tops of the hills are timber-covered. On the north side of the summit is a strip of prairie country. Outside of this prairie belt is more timber when the sandy Carboniferous strata come in, and along the bottoms of the creeks.

Geology.

Tishomingo granite.—South of Boggy P. O. in the Choctaw Nation, is an extensive area of granite, described by Hill, under the name of the Tishomingo granite. This granite, lithologically, is a muscovite, biotite granite and is very different from the hornblende granites of the Wichita mountains referred to previously. The Tishomingo granite is overlain by limestone, apparently of Silurian age. No evidence of the intrusion of the granite could be found, and it seems most probable that the limestone has been deposited on the surface of the granite.

Lower Silurian (Ordovician). A hard gray or bluish, coarse-grained limstone forms low hills on the south side of Boggy creek, eight or ten miles above Stonewall. From this locality the following fossils were collected: Orthis (Plesiomys fontinalis) White, Asaphus sp. (fragments), Bellerophon sp.

These strata can be referred to the lower portion of the Ordovician. Orthis fontinalis was described from strata of the age of the Quebec group.

Upper Silurian. The Lower Silurian limestone is overlain by flaggy cherty limestone. In one of the cherts a specimen of Strophonella was found. These cherts can probably be correlated with a series of beds, described by Mr. Hill in a publication later referred to, which furnished fossils identified by Prof. H. S. Williams as probably of Lower Helderberg age (p. 121). Collections subsequently made from an extension of this series into Indian territory show a varied and characteristic Lower Helderberg fauna.

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*Am. Jour. Sci., 3rd Ser., vol. XLII, p. 119, 1891.

Mr. Hill furnishes the following information concerning the pre-Carboniferous rocks of this region:

> Concerning the age of the pre-Carboniferous rocks only a little can be said but sufficient to confirm the impression that they include Trenton (No. 6), Niagara (No. 1), Lower Helderberg (No. 2). Could accurate collections be made, many other terranes would no doubt be shown to exist. The basis for these determinations are (sic) as follows: Near Woodford post-office, ten miles west of the railroad, I collected from strata which are continuous with and apparently the same as No. 2, the following fossils, kindly determined by Prof. H. S. Williams: Spirifera lamellosa, Strophomena rugosa (rhomboidalis), Rhynconella nucleolata, Lingula? rectilatera. Concerning these he says: "It is safe to say the horizon is Upper Silurian and probably equivalent to the Lower Helderberg of New York. It is above the Niagara, and this is an interesting feature." Concerning the fossils from No. 6, he says they are not very satisfactory but a Trinucleus concentricus shows No. 1092 *a* to be of Lower Silurian, probably Trenton age.
>
> It is not my desire to attempt any classification of these pre-Carboniferous rocks, but I believe from stratigraphic evidence that the shales at the south end of the gap may prove Devonian. Beneath the Trenton rocks are still older terranes, especially in the Red Bird mountains, which may be Cambrian.*

Taking the approximate determination of the Silurian beds from fossils collected by Mr. Hill in the Chickasaw and Choctaw Nations, and from those collected by myself in the Chickasaw Nation, Indian territory, and along the northern side of the Wichita mountains and at Ft. Sill, Oklahoma, it becomes evident that there is a great and probably quite complete sequence of these rocks.

According to Mr. Hill, there may be Cambrian in the Red Bird mountains. Lower Ordovician—perhaps Calciferous—is found on the north side of the Wichita mountains, and Low. Ordovician, about Quebec, on south side of Boggy creek, eight or ten miles above Stonewall.

Mr. Hill, as was stated in a previous quotation, found Trenton fossils. According to Dr. Girty the specimens from the Ft. Sill quarry are probably Trenton. Mr. Hill mentions Niagara and Lower Helderberg. According to Dr. Girty the Strophonella from the cherty limestone is probably of Silurian and most likely Lower Helderberg age.

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*Am. Jour. Sci. 3rd Ser., vol. XLII, pp. 121-122, 1891.

This résumé shows that probably there was an unbroken period of deposition throughout the Oklahoma-Indian territory region from the close of Cambrian to almost the close of Upper Silurian time.

No positive data have been accumulated concerning the existence of Cambrian in this region. The Devonian so far as we at present know is absent.

Carboniferous.—The flaggy, argillaceous, cherty, Upper Silurian limestone is succeeded by calcareous clays, which contain near Stonewall large nodules. These are fossiliferous and have furnished the following species:

Locality about 2½ miles west of Stonewall, Chicasaw Nation: Poseidonomya sp., Actinoceras sp., Goniatites choctawensis Shum. Orthoceras sp.

In nodules washed out of clay, Boggy creek, about 3 miles above Stonewall: Poseidonomya sp., Goniatites choctawensis Shum., Orthoceras sp.

Actinoceras sp. is an unusually large form, about six inches in diameter.

"The age of the shale in which these fossils occur has not yet been confidently determined, as the fauna is restricted and peculiar. The general facies is a Carboniferous one, and if the presence of Goniatites (Glyphioceras) choctawensis, which Shumard described as from the Coal Measures, and which is here identified with some confidence, be taken into account, the evidence might seem strong enough to warrant placing this horizon in the Coal Measures. But the possibility is entertained that Shumard may have been mistaken in referring G. (Glyphioceras) choctawensis to such a high horizon, and that this may be correlated with one of the black shales, as the Eureka or the Fayetteville, which have been recognized in Arkansas and in Indian Territory.* In this case the Mississippian era which so far as known does not otherwise occur, would be represented in this region.

The fauna from the black shale in the Indian territory in some ways resembles that from the black shale of the White Pine district, Nevada, from which Meek described Poseidonomya (?) fragosa, and Walcott subsequently identified Goniatites (Glyphioceras) kingi, which White described from the Coal Measures. Meek was in doubt whether this black shale belonged to the Devonian or Carboniferous, but leant toward the former conclusion. Walcott also cites it as Upper Devonian." (Girty.)

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*Leland Stanford Junior University Publications: Contributions to Biology from the Hopkins Seaside Laboratory, No. 14, 1898; A Geological Reconnaisance of the Coal Fields of the Indian Territory, by A. F. Drake, (reprint from Proc. Am. Phil. Soc., vol. 36, No. 156).

These shales are overlain by a thick series of sandstones, clays, etc., which have been studied in detail by Mr. J. A. Taff of the U. S. Geological Survey. Although I obtained some reconnoissance notes on the series, they will not be published, because of Mr. Taff's more thorough work.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

A Paleozoic Terrane beneath the Cambrian. By GEO. F. MATTHEW. (Annals N. Y. Acad. Sci., Vol. XII, No. 2, pp. 41-56.)

The author claims to have found beneath the beds containing Paradoxides and Protolenus (therefore below the Cambrian) a peculiar group of organisms which are sufficiently different in facies from the oldest Cambrian fauna to be considered as characteristic of an underlying and different system.

Sections of the terrane are given in which the discordance between it and the overlying Cambrian is shown. Two of these sections are in New Brunswick and two in Newfoundland.

The discordance in New Brunswick is shown by the complete erosion of the underlying terrane in some of the valleys where the Cambrian sediments occur, while in others the underlying terrane (Etcheminian) is 1,000 to 1,200 feet thick.

Similar conditions prevailed in Newfoundland, though there the thickness of the Etcheminian has not been ascertained. At Manuel brook, on Conception bay, the Etcheminian terrane is wanting and the Cambrian sediment, with Helmia (H. bröggeri) and Protolenus at the base, rest directly upon Huronian rocks (Intermediate system of A. Murray).

The condition of the sediments of the Etcheminian terrane, both in New Brunswick and in Newfoundland, indicates that there was only a slight induration of the clays and sands before the Cambrian time, though the calcareous beds had been quite consolidated. Hence erosion of the lower terrane was rapid in Cambrian time, and the limestone beds of the lower terrane furnished boulders to the conglomerates of the Cambrian.

The fauna of these Etcheminian beds is peculiar. If trilobites occur they are rare, as none were found in the examination of the faunas found at Smith's sound and in New Brunswick.

The following are stated to be the genera met with, Hyolithes 2 sp. Orthotheca 4 sp., Urotheca (n. gen.) 1 sp., Aptychopsis 1 sp., Rectorgina (?) 1 sp., Obolella 1 sp., Obolus 1 sp., Coleoides 1 sp., Hyolithellus 2 sp., Helenia 1 sp., Palaemœca 1 sp., Scenella 2 sp., Platyceras 3 sp., Modiolopsis 1 sp., Platysolenites (?) 1 sp.

Fragments of cystidians and burrows and trails of worms were also found, including Arenicolites and Psammichnites.

The Hyolithidæ are found to be of high type and well grown, so also are the Capulidæ; but the Gastropoda and Brachiopoda are small, and there is one minute crustacean.

Attention is called to the close resemblance of the Etcheminian sediments of Newfoundland to the lowest "Cambrian" bed in Massachusetts. Not only are the sediments alike but the faunas are similar. Four wood cuts accompany the article.

Wachsmuth and Springer's Monograph on Crinoids. By F. A. Bather. (Geological Magazine, N. S., Decade IV, vols. V and VI, London, 1898-9.)

It is not often that occasion arises for reviewing a review; but what purports to be a review of the Monograph on Crinoids is, in so many ways, so remarkable, coming from the source that it does, that it can be hardly allowed to pass unnoticed. In plan, in treatment of material and in nomenclature the great work was manifestly not built upon the ideals of the English critic. Since, however, the American authors did not see fit to consult others in these respects there do not appear any good reasons why they should come in for lengthy condemnation for such a course.

So many of the "corrections" are so trivial that it would seem that they would find a more appropriate place than the one in which they appear. The wonder is not so much that the critic found so much as he did but that he was unable, with his eagle eye, to pick out more. To one glancing over the "review" the most of it appears to be taken up in trying to convince the reader of the importance of certain Batherian views with which Messrs. Wachsmuth and Springer did not agree, and to which they evidently did not devote sufficient time in combatting.

Whether or not Mr. Bather's "corrections" will fulfill his "desire to increase the usefulness of a book" time alone will prove. The discussion of what the American authors did not say regarding the critic's published opinions leaves little reviewed of the essential portions of the Monograph. The keynote of the whole criticism seems to lie in the following statement: "Long ago I showed that their representation of my views was based on misconceptions, and again, while accepting a part of their criticism, took opportunity of restating my main position. By ignoring these protests in this monograph, Messrs. Wachsmuth and Springer have readily gained credit for the apparent demolition of my supposed theories. A short restatement of views already published by me may therefore be pardoned."

This, then, is certainly not strictly a review of the Monograph, but a wholly different thing.

It is difficult to fully understand just what such statements, as the following, mean. "The value of a work like the present depends less on the number of new forms it makes known, than on the care with which it revises previous descriptions, confirms or rejects previous proposals, and summarizes with lucidity the valid residue. It must have been a disappointment more bitter to the authors than it will be to their readers, when they found that they could not make a monograph even of so restricted a portion of the field either complete or authoritative. Long years of labor in field and study, the accummulation of literature in a western town, the unwearying collection and comparison of specimens new and old, all were deprived of their full and deserved effect when it was found impossible to examine a number of type-specimens, and when, during the very years that the work was printing, less careful or less learned writers were grinding out descriptions of species with a truly indecent haste. It was found impracticable to alter the manuscript to any great extent after it was first sent to the printers on September 1, 1894. Consequently it is very important that all species published elsewhere between that date and May, 1897, should undergo revision and comparison with species first described in the Monograph. Till this is done and till all type-specimens have been compared, we cannot look for a standard list of North American Camerate Crinoids."

Further on the critic proceeds to offer copious adverse comments because the authors did not include in their monograph certain changes that took place between the time when the completed manuscript was sent to the printer and the date on which the printed volumes were issued. He might with equal consistency have gone still further and criticised in the same way upon the "omissions" that have appeared since the work left the press!

One can fully and freely forgive Mr. Bather for all his vigorous use of the Queen's English, for his sharp comments and for his frequent flow of sarcasm, but so long as he dwells upon the surface of this earth of ours he can never be forgiven or forgotten for his irrepressible habit of always offering up his own interpretations of what he does not thoroughly understand in the works of other authors. This very bad propensity pervades not alone his "review" of the Monograph, but many of his other writings also.

For example: Regarding views expressed by Messrs. Wachsmuth and Springer on the genetic relationships of the forms of crinoids Mr. Bather observes: "Now my criticism of this Monograph is that it does not fairly represent the beliefs of its authors in these matters. They say, it is true, 'We have arranged our descriptions so as to place species which are most closely related next to each other' (p. 156). But if they have done this it has been in a very obscure fashion, and the same principle is far from being extended to genera". He then goes on to show how, in considering the species of Batocrinus the descriptions of those from the Warsaw limestone are followed by some from Lower Burlington, these by forms from the Kinderhook and these again by Upper Burlington types and so on in "erratic promenade."

Messrs. Wachsmuth and Springer make no claims that a stratigraphic arrangement is a genetic one. On the other hand, they have stated in no uncertain language that biotic relationships are not indicated by appearance in time of the species as we now know them. Every page of the Monograph shows distinctly that no attempt was made to array the descriptions of species in stratigraphic order. What object can there be in setting up such a man of straw and then proceed to lay violent hands upon him. It is utterly beyond all comprehension!

The English critic immediately goes on to dish up four pages more of "other slips of like nature." It is unnecessary to go into detail concerning them. On the whole they indicate familiarity neither with the geology, geography or literature treated of in the book. The Keokuk limestone is not beneath the Burlington. The horizon and locality ascribed to Batocrinus turbinatus, and its variety elegans are not incorrect. Both occur in the Lower Burlington limestone at Louisiana, Missouri, as stated in the Monograph. The species also occur at the same horizon at Burlington, Iowa, and Sedalia, Missouri, and twenty other localities.

Nor was "Keyes' reference in the Missouri report possibly copied from the Monograph." The Louisiana locality was given to Mr. Wachsmuth, along with some unusually fine specimens personally collected; and the Missouri report was written four years before the proof sheets of the Monograph were read.

A word in regard to the list of published writings of Charles Wachsmuth, which Mr. Bather appends to the "review" for the reason that "a list bearing this title has already been published in America, but it contains so many inaccuracies and deficiencies that the following bibliography may be welcome to students." The grave "omissions" consist of two papers read by title before the Iowa Academy of Science, which were never printed, or intended to be, and of which the secretary of the academy in the printed proceedings, included short explanatory notes of his own—one of five lines and the other of twice that number.

Casual perusal of the new "list" shows no less than 30 mistakes or "inaccuracies," besides four false statements, for which there is no reasonable, but one possible, excuse. No doubt Mr. Bather has been prompted by the most worthy and altruistic motives, though, if one were compelled to pass judgment on his "review" they could not be brought out with sufficient clearness.

For the concise statements of his own views on various questions all crinoid students will be under lasting obligations to Mr. Bather, and they certainly clear up many uncertain points. C. R. K.

Sveriges älsta kända Trilobiter, af JNO. CHR. MOBERG (Geol. Fören. i. Stockholm Förhandl. Bd. 21, Hft. 4, 1899).

Some years ago (1892) Dr. Moberg gave a short description of two species of Olenellus, which had been found in Skania in Sweden. In this article he gives a full description of these species, and refers one to the genus Holmia and the other conditionally to Schmidtia.

In connection with the study of these two trilobites he finds it necessary to revise the genera or subgenera, which have been taken out of (or established under) Olenellus.

In speaking of Olenellus in the extended meaning of the word, and of the separation of this group as a separate family from Paradoxidæ, as proposed by Mr. Walcott under the name Mesonacidæ, Moberg urges that the name should be Olenellidæ, as there is no more danger of confusing this with Olenidæ than of confounding Olenellus with Olenus.

Moberg adopts the divisions of Olenellus (sensu lato) as genera, making six types; viz:

ELLIPSOCEPHALA ASAPHOIDES Emmons.

OLENELLUS THOMPSONI Hall, to this he would attach *O. lapworthi* and *O. reticulatus* Peach.

MESONACIS VERMONTANA Hall.

HOLMIA KJERULFI Linrs., to this are added *H. broggeri* Walc., *H. callavii* Lap. and *H. lundgreni* Moberg.

SCHMIDTIA MICKWITZI Schmidt, to which may probably be referred *S. torelli* Moberg.

OLENELLOIDES ARMATUS Peach.

In reference to the above it may be observed that in place of Ellipsocephala Emmons, Moberg proposes the generic name GEORGIELLUS. This seems unnecessary as there is no need of confusing Elliptocephala with Ellipsocephalus, and Emmons is best honored by retaining his own name.

Also it may be observed that there are two types under Holmia, the first two species mentioned being distinguished from the type by a difference in the number of segments in the thorax, and by possessing a conical in place of a club-shaped glabella.

Three excellent plates accompany the article. On the first are shown the six types or genera of the Ollenellidæ recognized by Moberg, on the second the various parts of *Holmia lundgreni*, and on the third the parts of *Schmidtia* (?) *torelli*. G. F. M.

Några Calcitkristaller från Nordmarken af JNO. CHR. MOBERG. (Geol. Fören i. Stockholm Forhandl., Bd. 21, Hft. 4, 1899, 1 plate.)

In this article are described some peculiar calcite crystals; they are slender four-sided pyramids, on which are perched small six-sided prisms. G. F. M.

Palæontologiska notiser af GERHARD HOLM. *14. Om Bathmoceras.* (Geol. Fören i. Stockholm Forhandl., Bd. 21, Hft. 4, 1899).

In this paper Dr. Holm describes very fully the structure of a rare and peculiar Ordovician genus of cephalopods, found at the horizon of

Megalaspis limbata. The genus was originally described by M. Barrande, and both P. Fischer and H. Hyatt have written about it. An example had been found in the grey Vaginatum limestone by Angelin.

The structure of the siphon is very intricate, its sides being thrown into lobed folds that recall the septal plating of the Ammonites of later times. Eight plates of figures, showing in detail the peculiarities of the structure of the siphon, etc., accompany the memoir. G. F. M.

15. Om de åfre Graptolitskiffrarna på Kinnekulle

This article by the above author, and from the same press, describes the shales of Kinnekulle and their graptolitic contents. Linnarsson did much work in this district. Dr. Holm found here in the Rastrites shales, Monograptus 9 sp., Rastrites 1 sp., Climacograptus 1 sp., Diplograptus 4 sp. Prof. J. E. Marr has visited this place and written upon its fauna.

G. F. M.

MONTHLY AUTHORS' CATALOGUE
OF AMERICAN GEOLOGICAL LITERATURE. ARRANGED ALPHABETICALLY.*

Agassiz, Alexander.

The islands and coral reefs of Fiji. (Bull. Mus. Comp. Zool. vol. XXXIII, pp. 167, pls. 120, May, 1899.)

Bather, F. A.

Wachsmuth and Springer's monograph on crinoids. (Geol. Mag. collected extracts, 1898-99.)

Beecher, C. E.

Othniel Charles Marsh (Am. Jour. Sci., 4th ser. vol. 7, pp. 403-428, June, 1899.)

Brooks, A. H. (John E. Wolff and).

The age of the Franklin white limestone of Sussex county, New Jersey. (18th An. Rep., U. S. Geol. Sur., part 2, pp. 425-457, pl. 83, 1898.)

Clarke, W. F.

On Roscoelite. (Am. Jour. Sci. 4th ser. vol. 7, pp. 451-458, June, 1899.)

Curtis, G. C., and J. B. Woodworth.

Nantucket a morainal island. (Jour. Geol., vol. 7, pp. 226-237, April May, 1899.)

Dall, Wm. H.

A table of North American Tertiary horizons correlated with one another and with those of western Europe, with annotations. (18th Am. Rep., U. S. Geol. Sur., part 2, pp. 623-648, 1898.)

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*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Darton, N. H.

New developments in well-boring and irrigation in eastern South Dakota, 1896. (18th An. Rep., U. S. Geol. Sur., part 4, pp. 561-616, pls. XXXVIII-XLVII, 1898.)

Darton, N. H.

Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian. (U. S. Geol. Sur. Extract from the nineteenth annual report, 1897-98, part 4, pls. 74-118, 1899.)

Davis, W. M.

The Triassic formation of Connecticut. (18th An. Rep., U. S. Geol. Sur., part 2, pp. 1-192, pls. 1-20, 1898.)

Eakle, Arthur S.

Petrographical notes on some rocks from the Fiji islands. (Proc. Am. Acad. Arts and Sciences, vol. XXXVI, pp. 581-595, May, 1899.)

Emerson, Philip.

Notes on the New England upland about the White mountains. (Appalachia, vol. 9, pp. 52-58, May, 1899.)

Farrington, O. C.

A fossil egg from South Dakota. (Field Col. Mus., Geol. Ser., vol. 1, pp. 193-200, pls. 20 and 21, April, 1899.)

Gilbert, G. K.

Recent earth movement in the Great Lakes region. (18th An. Rep., U. S. Geol. Sur., part 2, pp. 595-647, pl. 105, 1898.)

Gilbert, G. K.

Boulder pavement at Wilson, N. Y. (Jour. Geol., vol. 6, pp. 771-775, Nov.-Dec., 1898.)

Gilbert, G. K.

Glacial sculpture in western New York. (Bull. Geol. Soc. Am., vol. 10, pp. 121-130, Mar. 23, 1899.)

Gilbert, G. K.

Dislocation at Thirty mile point, New York. (Bull. Geol. Soc. Am., vol. 10, pp. 131-134, Mar. 23, 1899.)

Gilbert, G. K.

Ripple marks and cross-bedding. (Bull. Geol. Soc. Am., vol. 10, pp. 135-140, Mar. 23, 1899.)

Glenn, L. C.

The Hatteras axis in Triassic and in Miocene time. (Am. Geol., vol. 23, pp. 375-379, June, 1899.)

Goode, J. Paul.

The piracy of the Yellowstone. (Jour. Geol., vol. 7, pp. 261-272, Ap.-May, 1899.)

Hayes, Willard.

Physiography and Geology of the region adjacent to the Nicaragua Canal route. (Bull. Geol. Soc. Am., vol. 10, pp. 285-348, pls. 30-32, May 5, 1899.)

Hershey, O. H.

Observations on dirt storms. (Am. Geol., vol. 23, pp. 380-382, June, 1899.)

Hillebrand, W. F., (and H. W. Turner).

On Roscoelite. (Am. Jour. Sci., 4th ser., vol. 7, pp. 451-458, June, 1899.)

Hill, R. T., and T. Wayland Vaughan.

Geology of the Edwards plateau and Rio Grande plain adjacent to Austin and San Antonio, Texas, with reference to the occurrence of underground waters. (18th An. Rep., U. S. Geol. Sur., part 2, pp. 194-321, pls. 21-64, 1898.)

Jefferson, Walter D.

A certain type of lake formation in the Canadian Rocky mountains. (Jour. Geol., vol. 7, pp. 247-261, April-May, 1899.)

Jefferson, Mark S. W.

Beach cusps. (Jour. Geol., vol. 7, pp. 237-246, April-May, 1899.)

Knowlton, F. H.

The fossil plants of the Payette formation. (18th An. Rep., U. S. Geol. Sur., part 3, pp. 721-736, pls. 99-102, 1898.)

Lambe, Lawrence M.

On reptilian remains from the Cretaceous of Northwestern Canada. (Ottawa Naturalist, vol. xiii, pp. 68-70, June, 1899.)

Leverett, Frank.

The water resources of Indiana and Ohio. (18th An. Rep., U. S. Geol. Sur., part 4, pp. 419-559, pls. 33-37, 1898.)

Leverett, Frank.

Wells of northern Indiana. (Water Supply and Irrigation Papers, U. S. Geol. Survey, No. 21, 1899.)

Leverett, Frank.

Wells of southern Indiana. (Water Supply and Irrigation Papers, U. S. Geol. Sur., No. 26, 1899.)

[Lewinson-Lessing.]

Lewinson-Lessing's classification of rocks and differentiation of magmas. (Anonymous review. Am. Geol., vol. 23, pp. 346-369, June, 1899.)

Lindgren, Waldemar.

The mining districts of the Idaho basin and the Boise ridge. (18th An. Rep., U. S. Geol. Sur., part 3, pp. 619-719, pls. 87-102, 1898.)

Logan. W. M.

Contributions to the paleontology of the Upper Cretaceous. (Field Col. Museum, Geol. Ser., vol. 1, pp. 207-216, pls. 22-26, April, 1899.)

Lord, E. C. E.

Petrographic report on rocks from the United States-Mexico boundary. (Smith. Inst. Proc. U. S. Nat. Mus., vol. 21, pp. 773-782, pl. 85, 1899.)

[Marsh, O. C.]

Othniel Charles Marsh. By C. E. Beecher. (Am. Jour. Sci., 4th ser., vol. 7, pp. 403-428, June, 1899, portrait.)

Matthew, Geo. F.

A paleozoic terrane beneath the Cambrian. (Annals N. Y. Acad. Sci., vol. XII, pp. 41-56, Apr. 22, 1899.)

Monroe, Charles E., and Edgar E. Fuller.

The fauna of the Devonian formation at Milwaukee, Wis. (Jour. Geol., vol. 7, pp. 272-284, April-May, 1899.)

Moses, Alfred J.

The characters of crystals: an introduction to physical crystallography, octavo, pp. viii, 211, New York, Van Nostrand & Co., 1899.)

[Mudge, Prof. Benjamin F.]

Prof. Benjamin F. Mudge, by S. W. Williston. (Am. Geol., vol. 23, pp. 339-345, portrait, June, 1899.)

Nichols, H. W.

The ores of Columbia, from mines in operation in 1892. (Field Col. Mus., Geol. Ser., vol. 1, pp. 125-177, map, March, 1899.)

Pirsson, L. V., (W. H. Weed and).

Geology and mineral resources of the Judith mountains of Montana. (18th An. Rep., U. S. Geol. Sur., part 3, pp. 439-616, pls. 69-86, 1898.)

Purington, C. W.

Preliminary report on the mining industries of the Telluride quadrangle, Colorado. (18th An. Rep., U. S. Geol. Sur., part 3, pp. 747-848, pls. 103-118, 1898.)

Reid, Harry Fielding.

The variations of glaciers. IV. (Jour. Geol., vol. 7, pp. 217-225, April-May, 1899.)

Riggs, E. S.

The Mylagulidæ; an extinct family of sciuromorph rodents. (Field Col. Mus., Geol. Ser., vol. 1, pp, 181-187, March, 1899.)

Russell, I. C.

The glaciers of Mount Rainier. (18th An. Rep., U. S. Geol. Sur., part 2, pp. 349-415, pp. 65-82, 1898.)

Safford, James M., (and Charles Schuchert).

The Camden chert of Tennessee and its Lower Oriskany Fauna. (Am. Jour. Sci., 4th Ser., vol. 7, pp. 429-432, June, 1899.)

Schuchert, Charles, (James M. Safford and).

The Camden chert of Tennessee and its Lower Oriskany Fauna. (Am. Jour. Sci., 4th Ser., vol. 7, pp. 429-432, June, 1899.)

Shaler, N. S.

Geology of the Cape Cod district. (18th An. Rep., U. S. Geol. Sur., part 2, pp. 497-593, pls. 97-104, 1898.)

Shaler, N. S.

Formation of dikes and veins. (Bull. Geol. Soc. Am., vol. 10, pp. 253-262, Apr. 17, 1899.)

Shaler, N. S.

Spacing of rivers with reference to hypothesis of base leveling. (Bull. Geol., Soc. Am., vol. 10, pp. 263-276, Apr. 17, 1899.)

Shaler, N. S.

Loess deposits of Montana. (Bull. Geol. Soc. Am., vol. 10, pp. 245-252, April 17, 1899.)

Smith, Geo. O.

The rocks of mount Rainier. (18th An. Rep., U. S. Geol. Sur., part 2, pp. 416-423, 1898.)

Smith, W. S. F.

A geological sketch of San Clemente island. (18th An. Rep., U. S. Geol. Sur., part 2, pp. 459-496, pls. 84-116, 1898.)

Smyth, C. H. Jr.

Geology of the Adirondack region. (Appalachia, vol. 9, pp. 44-51. May, 1899.)

Teller, Edgar E., (Charles E. Monroe and).

The fauna of the Devonian formation at Milwaukee, Wis. (Jour. Geol., vol. 7, pp. 272-284, April-May, 1899.)

Turner, H. W., (W. F. Hillebrand and).

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New method of estimating the age of Niagara Falls. (Pop. Sci. Month., vol. 55, pp. 145-154, June, 1899.)

PERSONAL AND SCIENTIFIC NEWS.

Prof. F. W. McNair of the Michigan College of Mines, was recently elected president of the institution, *vice* M. E. Wadsworth resigned last year. Prof. McNair has been for some years connected with the institution as professor of mathematics and physics.

Dr. U. S. Grant, one of the editors of the American Geologist, and for fourteen years connected with the geological survey of Minnesota, has been elected professor of geology and curator of the museum at Northwestern University, Evanston. Dr. Grant is a large contributor to the forthcoming final volumes IV, and V of the Minnesota report.

Dr. Charles R. Keyes has been engaged for some time past in making investigations regarding the adaptability of certain coals for gas-making purposes. The inquiry extends over Iowa, Missouri, and Kansas and will soon be extended into Arkansas and Indian territory. The company under whose auspices the experiments and field work is being conducted have some new processes whereby it is believed that many of the coals not now available can be utilized to great advantage. So far the coals selected by Dr. Keyes have met with great success.

Professor E. M. Shepard of Drury college and late of the Missouri geological survey has returned from a several months' geological trip to the Hawaiian islands, New Zealand, and Australia. The special aim of the trip was to study active volcanoes and to examine coral islands. The glaciers of New Zealand came in for detailed examination. Many beautiful photographic views were taken. Some of these show the phenomena in a manner that cannot be surpassed. Altogether the trip was a very successful one in every respect, and some of the results will doubtless appear before long.

Dr. H. F. Bain has recently returned from a month's geological reconnaisance in the Ouichita mountains of Indian territory where he had charge of a party of engineers and experts who were engaged in making surveys for certain devolopment companies. Aside from the strictly economic aspects many interesting observations of special geological interest were made. An elaborate report is being prepared on the properties examined.

D. L. Wilder, instructor in the west Des Moines high school, and a graduate of Oberlin college, has lately been appointed assistant on the Iowa geological survey. This season will be spent in northwestern Iowa in study of the glacial deposits and the Cretaceous.

Assistant Professor Curtis F. Marbut of the Missouri State University has been promoted to the full professorship in that institution and has been granted a leave of absence for one year. He sails shortly for Europe where he will remain until after the International Geological Congress at Paris. Most of the year he expects to spend in German Universities, but much time will be devoted to visiting classical geological localities.

Prof. J. E. Wolff will spend the next college year abroad, leaving early in the autumn. His work in mineralogy and petrography at Harvard University will be conducted during his absence by Charles Palache and Dr. A. S. Eakle. Dr. Palache is at present in Alaska with the Harriman expedition. Dr. T. A. Jaggar. Jr., of the same institution, has again gone west, on problems presented by the stratigraphy and intrusives of the Black hills.

Mr. J. B. Woodworth, after completing some areal work in Massachusetts, will conduct a party of students for geological study in Montana, during July and August. He has been engaged during the spring in bringing together the results of his studies upon the sand-plains of New England.

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Oliver Marcy

THE AMERICAN GEOLOGIST,
Vol. XXIV, Plate IV.

THE

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VOL. XXIV. AUGUST, 1899. No. 2

OLIVER MARCY, LL. D.

By A. R. CROOK, Evanston, Ill.

(Portrait)

A few years ago at the opening exercises of the Northwestern university, as one member of the faculty after another arose to make announcements concerning the work of his department for the beginning collegiate year, a new comer on the teaching force, taking first impressions of the men who were to be his colleagues, heard a senior behind him remark, as a fine looking, white haired professor arose to announce work in geology, "There is the finest man in the faculty. He has helped me more than any other man living."

If the senior's expression voiced a student's sentiment when the professor was past the alloted three score years and ten, it may convey an intimation of the popularity and influence of the professor at the period of his greatest activity and power. It is said that when Dr. Marcy was acting president of the university no student felt that graduation could properly come to one who had not taken work under him.

Oliver Marcy was born at Coleraine, Mass., Feb. 13, 1820, and died at Evanston, Ill., March 19, 1899. He was the seventh of nine children born to Thomas Marcy. His father died when the lad was eight years of age. The mother must have been an unusual woman, for she managed to bring up a large family in such a manner that it became an honor to her and a blessing to the community. The daughters were well married. Three of the sons obtained a college education. Two of them became ministers of the gospel and one a college professor; and of these three, two were at one time college presidents. That the Marcys were good stock is evident to one looking over the "Record of the Marcy Family."* Members of the family have been prominent in church and state. Among them have been a high sheriff, captain, general, member of supreme court, governor, U. S. senator, secretary of state, doctors, ministers, college professors and presidents, lawyers and explorers.

Oliver obtained his early education in the common schools of his native town. By practicing strict economy and self denial and by working during vacation he was able to complete a college course at Wesleyan university, and to graduate with the degree of A. B. at the age of twenty-six. The following year he married Elizabeth E. Smith, of Chatham, a woman of rare qualities of mind and heart, a true companion and helper through their long married life, a lady who has found time and strength to carry on a great work among the poor of Chicago, and to whom the Chicago Bohemian Mission will long be a monument.

It had early been Mr. Marcy's intention to become a teacher. The first position which came to him was that of instructor in mathematics at Wilbraham (Mass.) academy. After a year or two in addition to his other work a class in geology was assigned to him, and that was the beginning of his interest in a subject which afterward became his chief interest.

Sixteen years had been spent in teaching at Wilbraham, when he was elected, in 1862, to a professorship of natural science in the Northwestern university. These were the days when one man had to handle a multitude of subjects in western colleges, and Prof. Marcy was called upon to teach geology, mineralogy, zoology, botany, physics, chemistry, mathematics, logic, philosophy, moral science, and natural theology—almost as large a number and as great a variety of subjects as claimed the attention of Immanuel Kant, at Königsberg, one hundred years before.

Twice he was acting president of the university, serving the first time for five years ('76-'81), and the second time for part of a year ('90). For nearly two score years he was actively connected with the university. His own growth and development were contemporaneous with the passing of the day of small things to a time of greatness in the institution. When he was elected there were eight teachers and thirty-one students; at the time of his death the faculty numbered two hundred twenty-nine, and the students more than two thousand.

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*New England History and General Register, July, '75. Communicated by Prof. Oliver Marcy, LL. D.

His work in geology was begun and continued under surroundings and conditions that were far from auspicious. He had been teaching for forty-six years before he was able to give his chief attention to his favorite subject. When he began his study of geology the many well written and profusely illustrated text books that are to-day within the reach of the student, did not exist. Books were expensive. But Dr. Marcy bought so many that the principal of Wilbraham, Miner Raymond, mildly reproved him for extravagance.

Mantell had not yet written his Medals of Creation; Hugh Miller's Testimony of the Rocks did not appear till '56, and the Old Red Sandstone not until two years later. Dana did not begin to bring out his books until Marcy had been teaching a dozen years. Lyell's Principles of Geology had passed through several editions, but seems not to have come within Marcy's reach, so that his early knowledge of the science was derived almost wholly from Buckland's Mineralogy and Geology, and Buckland was a catastrophist.

Wilbraham had no museum and Marcy found it necessary to go twenty miles to Amherst to find specimens illustrating the principles of the science. And later, upon coming to Evanston, he found the Northwestern university without a museum. The building of a museum was a great work, involving much patient and careful work, little appreciated by the uninitiated. During the course of his labors he labelled and classified more than seventy thousand geological, botanical, archæological and geological specimens. The museum stands as an enduring monument of his activity and knowledge.

His varied duties as curator, teacher of many subjects, and president of the university, left little time for investigation or for literary work; consequently the printed products of his pen fail to represent his activity or his attainments. About sixty articles, which he wrote chiefly for weekly papers, have come under my notice, and they give an insight into his character, the conditions which surrounded him and the problems which he had to solve.

Half a dozen of the articles are metaphysical in nature—Sophistry, Concept of God, Beauty, Truth, Spencerian Ethics, Vital Force—showing that speculative philosophy had strong attractions for him.

A large number of the articles plead for a wider place in the college curriculum for natural science subjects. His work began at a time when Cerberus was trying to keep the youthful natural science thoroughbreds from the manger and much energy and thought were necessary to gain a proper recognition of the value of scientific studies. One of the best of his articles, entitled Science-Education* presents many interesting facts and with a true philosophical spirit shows the importance of natural science in a college course.

The greater number of the articles were upon geological subjects—Mammoth cave, Lou Lou trail (Idaho), vicinity of Evanston, the museum, etc. Some of them would misrepresent the author to the reader who did not appreciate the fact that the articles recorded the growth of the author rather than his final position.

For example, at one time he was a catastrophist like his teacher, Buckland, for he says, "Not a single species passed the line——" (close of Devonian). "Every living thing in all the seas of the world had died and the swarming millions whose remains filled the rocks above had been brought into existence by the creative fiat."† In numerous articles he opposed "mechanical evolution," and believed as Lyell at one time did, and Dawson continued to do, in the ice-berg theory of the causes of phenomena now known to be due to glacial action. Yet so diligent a student was he, so scientific in spirit, so free from bigotry and dogmatism, that he kept abreast of the progress in his science; and his students and those most intimate with him know that he adopted the views of the majority of the geologists of to-day, that he was convinced of the error of the idea of cataclysm and taught gradual development along an unbroken chain of life, and that he accepted and advocated the theory of mechanical evolution.

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*Illinois Schoolmaster, March, 1874.

†Northwestern Christian Advocate, Aug. 17, '64.

Many of the revisions of his thought came at a period in life when most men cling to the conclusions which they have acquired, whether the facts warrant the conclusions or not. This reasonableness of his character, together with his diligence as a student and the strength of his memory enabled him to become not only a well informed geologist, but in truth a profound scholar in the science.

The only scientific monograph which he published was one* on the fossils of the Chicago Niagara limestone, prepared in conjunction with Alexander Winchell, and presented at the Boston Society of Natural History in 1865. It is a satisfactory paper in every way.

Dr. Marcy will not be longest remembered as an author nor as a traveler. The only extended journey which he made was with a U. S. survey party to the Pacific coast, by way of Panama, as far north as Washington and across the Bitter Root mountains, between Idaho and Montana. The only account of this trip was published in the college paper, and in the museum report for 1887. But he brought back much interesting material for illustration and a supply of observations that added to the charm of his class room and the wealth of the museum.

It is as a teacher that he will be longest remembered. He dealt with interesting subjects in an interesting manner, and was able to arouse enthusiasm among his students. He was approachable, being willing to spend unlimited time and labor with the interested inquirer, and showing a zeal for the character as well as scholarship of the student. His voice was strong and pleasing; his manner clear and distinct. He was not critical in small things; was large minded, just, straightforward, generous, and had an open handedness and guilelessness that drew men toward him. There was little selfseeking in his nature, and losing himself in his work and in the interests of others, he found his own highest good. For few men have been more fortunate in receiving all through life the respect and love due them. Many honors came to him. He was a member of the Phi Beta Kappa, of the American Association for the Advancement of Science, a Fellow of the Geological Society of America, received the degree of Doctor of Laws from Chicago University in 1873, was dean of the College of Liberal Arts of Northwestern University for twenty years, and twice held the position of acting president. A fossil oak (Quercus marcyana) and a hill in Massachusetts are named in his honor.* Expressions of appreciation were not withheld by his friends till after his death. He was constantly receiving them, and upon the occasion of his seventy-eighth birthday the alumni presented his portrait to the university.

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*"Enumeration of Fossils collected in the Niagara Limestone at Chicago." Prof. Alexander Winchell and Prof. Oliver Marcy. Boston Society Natural History Memoirs, vol. I, pp. 81-114, 1866-1869.

The occasion was an impressive one. The beautiful library room, adorned with the university colors and flowers, and brilliant with electric lights, had been arranged with tables, at which sat about two hundred guests. The white haired, fine looking gentleman whose birthday was being celebrated, sat beside the president of the university, and after several speeches that expressed the respect and love of students, alumni, acquaintances, and friends, and the unveiling of the portrait, received such an ovation as rarely comes to a professor.

His death called forth expressions which showed the breadth of his influence. The funeral services were rarely impressive He lies buried under the hemlocks in a wild and picturesque ravine on "Mt. Marcy," at Wilbraham, Mass.

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*Mt. Marcy, in Montana, is named in honor of Gen. R. B. Marcy.

AGE AND ORIGIN OF CERTAIN GOLD DEPOSITS ON THE ISTHMUS OF PANAMA.

By Oscar H. Hershey, Freeport, Ill.

Nearly all the workable gold-bearing quartz veins of the isthmus of Panama, west of the line of the Panama railway, are found in two main belts one on the northern flank of the Cordillera de Veraguas and the other in the foot-hills belt on the southern side of the great sierra. Both are long and comparatively narrow, and trend in an east-west direction, parallel to the main mountain axis. There is nothing singular about the occurrence of the gold or its mode of derivation in these belts, but the veins are of such recent origin, as compared with gold-bearing ledges in most other districts of the earth, as to be of more than mere local interest.

The Cordillera de Veraguas, on the line of the old Santa Fe and Cocuya trail, about 120 miles west of Panama, is an immense igneous mass, probably twenty-five miles in width. Once a high narrow plateau, stream dissection has converted it into an extremely rugged mountain system with a crest-line 5,000 to 8,000 feet in altitude, and valleys 1,500 to 2,500 feet in depth Three rock types are chiefly represented. Specimens of them have been identified for me by Dr. U. S. Grant, as follows: In the valley of the Rio Santa Maria, on the southern slope of the range, the formation is mainly rhyolyte of light color. On the northern slope there is a great massif of rock "composed mostly of flesh-colored feldspar, with some biotite and perhaps a little hornblende or augite," appearing like some of the nepheline syenytes. On the continental divide, locally known as the Sierra Balcazar, and again about the headwaters of the Rio de los Saltos and the Rio Santiago, on the northern edge of the mountain complex, there is another great massif, whose rock has been doubtfully identified by Dr. Grant as andesyte, although, upon closer examination, he thinks it may prove a trachyte or even a diabase. Dr. C. P. Berkey says it very closely resembles one of the diabases found at Taylor's Falls, Minn. As for myself, from an examination of the formation in the field, I prefer to consider it a diabase. The relation between the three rock types is not well made out, but the fine-grained diabasic portion of the mountain formation appeared to bear a relation to the crystalline rhyolyte and syenyte somewhat as a thick cap-rock or original covering. However, it is beyond question that the entire width of the range on this line is made up of igneous rocks of a deep-cooling rather than a "surface volcanic" nature. They constitute the "Veraguas formation" which, from its relation to other geologic features of the isthmus country, I consider of early Tertiary age, probably Eocene; certainly not so old as the Cretaceous period.

The diabase and syenyte of the Veraguas formation extend beyond the mountains on the north to form the cañoned, seaward sloping, piedmont belt. It is at and in the near vicinity of the junction between the sierras and this dissected plain that is situated the northern or Veraguas gold-belt, extending along the edge of the mountain country for a distance of perhaps 150 miles, yet probably averaging in width no more than two or three miles. It is the richest on the isthmus, but owing to the dense, jungle-like vegetation, and the daily rains is not now mined. All the streams, issuing from the mountains and crossing the quartz belt, are rich in placer gold, and some were mined for hundreds of years, by the Spaniards and Indians. From the universal forest covering, the quartz veins are difficult to find, and not many have yet been uncovered. Those examined by me were chiefly on the headwaters of the Rio Santiago. They were fissure veins, generally about vertical, and varying in width from several inches to two feet. The gold bearing quartz is white and the gold is free. Associated with these white veins, are thin stringers of heavy iron and manganese sulphurets. Curiously, these pyritous ores are nearly barren of gold. None of the veins observed were connected with detectable faults or contacts.

The important points to which attention is to be drawn are, that the mineral belt passes indiscriminately across the areas of the diabase and syenyte, and that similar quartz veins occur in the same formations on both sides of the gold-belt and yet are practically barren. If the gold has been derived from the enclosing formations, why is it not abundant throughout the areas of these formations, particularly in the interior of the Cordilleran region?

The southern or Remanse gold-belt has been traced, and hundreds of veins located, between the villages of San Francisco and Cañazas, a distance of about twenty-five miles. It lies near the southern edge of the treeless and barren foot-hills belt, probably twenty miles from the high sierras. The rocks of this belt are a complex series of "surface volcanics" water-laid tufas, coarse ashes, trap porphyries, basalts, etc.,—which extend in a broad belt eastward along the southern side of the Cordillera de Veraguas, and then adjoining the Pacific ocean to the city of Panama, between which and the Culebra cutting on the proposed Panama canal, they have been studied by Mr. R. T. Hill* and by him named the Panama formation. He considers it of Cretaceous age. My own studies, carried on independently and without a knowledge of his, tend to place it in a later period, probably the Eocene. Certainly, in the provinces of Veraguas and Cocle, 90 to 150 miles west of Panama, a fossiliferous late Cretaceous formation is separated from an overlying series of purple conglomerate, red sandstone and red shale, by an erosion unconformity of no mean value; and the red series (apparently Eocene) was clearly observed to pass under the white and gray, water-laid, rhyolitic tufas of the Panama series. I shall, therefore, consider the formations of the Remanse gold-belt as most probably of Eocene age.

The representative mine of this belt is that known as the Remanse, owned and operated by an English company. In a space of perhaps one-fourth square mile, there is one main vein, four to fifteen feet in width, and as much as ten smaller veins or stringers to the main ledge, each of which is capable of constituting a paying mine. The main vein is straight, nearly vertical, has been penetrated at a depth of 600 feet beneath the surface and contains white quartz with little or no sulphurets, but an average gold content of $16 per ton. To me the curious features of this mine are, that the main vein is connected with a horizontal fault, and that the enclosing walls are white, compact, fine-grained, water-laid tufa, macroscopically resembling chalk. The American miner will easily recognize the rather unusual conditions here, namely, a gold-bearing vein of quartz cutting a soft volcanic ash of Tertiary age.

Fifteen miles farther west, at Cañazas, the gold veins are in a variety of rock types, sometimes a tufa, but oftener a gray, crystalline, volcanic rock of somewhat doubtful mode of formation. Indeed, from my studies of this Remanse belt, I should say that the gold-bearing quartz veins are chiefly associated with the white and gray tuffs only because they are the predominating formations of the district. The same series of formations extend without change for many miles in all directions, and apparently the same system of quartz vein is well developed and finely exposed in places; yet outside of this one narrow belt there is known to be little or no gold; at least, nothing comparable with the Remanse district. Why is it? If the gold was derived by segregation, or any other process, from the enclosing country-rock, why should it be confined to this particular strip of country, which apparently has no dependent relation to the present topography or to any system of faults or folds in the surface portion of the rocky strata?

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*Bulletin of the Museum of Comparative Zoology, at Harvard College, vol. XXVIII, No. 5.

In the course of a period of practical prospecting work, I have had it forcibly brought to my notice that gold occurs, in different districts, or even in one district, under remarkably diverse conditions, and that while one study may yield clear evidences that a given deposit of gold-bearing quartz has derived its mineral contents from the enclosing formation, another study, made at some distance, may yield equally as clear evidences that there the country-rock had nothing to do with the gold. It is for this reason that the study of individual districts is of such interest and importance.

It is a matter of common observation among miners that gold-belts are more likely to occur on the lower slopes or flanks of high mountain ranges than in the central and higher portions of the disturbed areas. This is finely illustrated in the two cases from the isthmus of Panama, now under consideration. Here I attribute it to the following: As the gold, both in the Veraguas and the Remanse belt, came not apparently from the adjacent country-rock, it must have been derived from some deep-lying portions of the same or other stratified series. This implies deep-extending fissuring and faulting on the line of the belts. Such a crushing of the rocks would be less likely to occur near the axis of the broad arched "upthrust" of the Cordillera de Veraguas, and under the lowlands on either hand, than on the flanks of the uprising area. Hence, we may suppose that the long, narrow Veraguas and Remanse gold-belts represent the line of maximum strain and greatest crushing of the strata, each on its side of the range. Up through these profound fissures (which may not show at the present surface) came the heated, gold-and-quartz-bearing solutions to form the veins of those districts.

Now, however, in the Remanse belt we find that most of the veins are north-south instead of east-west in trend; that is, they are transverse to instead of parallel with the mountain axis. This I attribute to more or less of a twisting motion which served only the more effectually to crush the strata under the Remanse belt. That this twisting motion was a reality in one instance at least, is indicated by the fine example of a horizontal fault* at the main Remanse mine.

The language that I have used in the preceding paragraphs must not be construed as indicating any intentional opposition on my part to the "lateral secretion" theory as applied to many mineral veins in the United States; all that I contend in this paper is that in this one particular portion of the earth, namely, the provinces of Veraguas, Cocle and Colon, on the isthmus of Panama, the evidence is predominantly in favor of the hypothesis that the mineral solutions came from a great depth, and that the gold was not to any great extent derived from the adjacent country-rock; this assertion I make regardless of whether the porphyries, tuffs, diabases and syenytes of that country contain disseminated gold of a primary origin. If it is true, the veins of the two districts may be expected to hold out with depth, (just as the Remanse does at 600 feet,) and the gold near the present surface may be but a slight indicative of the stores of mineral wealth buried in the greater and more persistent fissures below.

After the Panama and Veraguas formations were completed and elevated, subaërial erosion, acting rapidly on the land surface, produced what appears to have been a peneplain. Sometime in the Tertiary era, probably about the Miocene period, this was elevated and has since been dissected to form the present mountainous character of the country. The gold-bearing quartz veins were formed before the planation of the volcanic region, and hence must be early Tertiary in age.

May 23d, 1899.

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*By a "horizontal fault" I do not mean one whose plane is horizontal but a vertical or nearly vertical fissure whose walls have moved horizontally instead of vertically as in ordinary faults.

LEPTICHTHYS, A NEW GENUS OF FISHES FROM THE CRETACEOUS OF KANSAS.

By Alban Stewart.

Family HALECIDÆ.

LEPTICHTHYS gen. nov.

There are several specimens in our collection that evidently belong to this family, which seem to differ from any of the other genera referred to it for which I will venture to propose the generic name of *Leptichthys*. This genus seems to be closely related to *Osmeroides*, Agassiz, from the Chalk of Syria and England, but differs from it in the presence of a short dorsal fin and nonstriated scales. It also differs from *Apsopelix*, Cope, in the anterior position of the dorsal fin.

The body is ellipsiform and covered with large and thin cycloid scales, which are concentrically striated ventrally but seem to lose this character to some extent in the dorsal region where they are somewhat rugosely marked. The pelvic bones seem to be formed of heavy transverse bars of bone which are thickened externally for the attachment of the pelvic fin. These bones probably have some anterior extension, but how much cannot be ascertained from our specimens. The dorsal fin is short and composed of numerous rays which are situated in front of the middle portion of the body. The pectorals are broad and rather elongated. The pelvic fin is broad, short, and is composed of a less number of rays than the pectoral. There are no remains of anal fins in any of our specimens, but they will doubtless be found in more completely preserved individuals. The caudal fin is deeply cleft. The skull seems to be rather bluntly pointed in front. The dentaries are short with acutely pointed teeth, and the lower borders of the bone are directed upward in front giving the chin a somewhat rounded appearance. The vertebræ are two-grooved and longer than deep.

LEPTICHTHYS AGILIS, sp. nov.

Scales large, about ten or twelve series to be seen across the body. Pectoral fins composed of at least fourteen rays, the first two or three of which are cross-segmented while the remainder are longitudinally split. The pelvic fins are situated posteriorly and the cross-segmentation is absent from its rays. The dorsal fin is composed of twelve or more bony rays.

Measurements.

	mm.
Length of body to cleft of caudal fin	290.
Length from anterior extremity to base of dorsal fin	112.
Depth of body at dorsal fin	59.
Length of pectoral fin	46.
Width of pectoral fin at base	16.
Length of pelvic fin	29.
Width of pelvic fin at base	10.
Length of mandibular rami	32.

Lawrence, Kansas, May 15, 1899.

GLACIAL HISTORY OF THE NEW ENGLAND ISLANDS, CAPE COD, AND LONG ISLAND.

By Warren Upham, St. Paul, Minn.

The collective name, New England islands, proposed in recent papers by Mr. J. B. Woodworth and Prof. N. S. Shaler, designates the islands lying south and southwest of the peninsula of Cape Cod and south of the state of Rhode Island, including Nantucket and Martha's Vineyard, the small islands associated with them, the Elizabeth islands, and Block island. These islands, and Long Island, stretching farther west to the Narrows at the entrance of New York bay, and also the neighboring shores of Rhode Island, the peninsula of Cape Cod, and a large area of Plymouth, Bristol, and Norfolk counties, Mass., extending from Cape Cod (Barnstable county) northwesterly to Boston harbor, I examined during the years 1877 and 1878, for comparison with the drift formations of New Hampshire (Geology of N. H., vol iii, 1878, pp. 300-305). Ever since then, my interest in the glacial geology of that region has continued, because I found it to have a most admirable development of the terminal moraines of the continental ice-sheet, which were traced, in part a little earlier and in part a little later, by Smock, Lewis, Wright, Chamberlin, Leverett, the present writer, and others, from Staten island and northern New Jersey west to Illinois and northwest to Wisconsin, Minnesota, the Dakotas, and Manitoba. Professor Shaler, in his recent paper, "Geology of the Cape Cod District" (Eighteenth Annual Report, U.

S. Geol. Survey), discusses somewhat elaborately the glacial history of the Cape Cod peninsula and of the contiguous New England islands; and his conclusions differ widely, in several ways, from those which seem to me, and partially, at least, to some other glacialists, demonstrable or highly probable. The present paper is contributed to this discussion, with all due respect but as the performance of a duty, that these alternative views may be compared with the explanations offered by Prof. Shaler, who confesses that much difficulty besets his interpretation of the glacial record in that region.

As a summary is here attempted, rather than detailed descriptions of the drift formations and special application of principles to explain each in its varying development, the student should refer to the literature of this subject, for which purpose a list of authors and papers is appended. Citations of opinions of these authors will therefore not require foot-note references to their place and date of publication. For convenience of statement, the questions considered are presented in five parts or divisions, each of which is treated as concisely as appears practicable, omitting of necessity much amplification which might make my meaning and the evidences in support of my arguments more clear. Limits of space also forbid my expression, excepting at this place, of my high appreciation of Prof. Shaler's great ability in reasoning, his courage in stating his results, and their attractive form, in this and in all his abundant literary work, winning always a wide range of readers.

Epeirogenic Movements causing Glaciation.

Immediately south of the west end of Long Island, the submarine continuation of the Hudson river valley across the outer part of the continental slope, to the distance of a hundred miles southeast of Sandy Hook, proves a great epeirogenic uplift of this region. The gently declining submerged plain, continuous with the Cretaceous and Tertiary coastal plain of New Jersey and the more southern Atlantic states, is trenched by a well defined valley which has a moderate depth for seventy-five or eighty miles and beyond sinks to a maximum sounding of 2,844 feet near its opening into the abyssal ocean. The margin of the continental plain has soundings of 600 feet, beneath which the ancient Hudson valley, along its outermost twenty-five miles, would exhibit, if uplifted as when the river flowed there, a cañon channeled 2,200 feet in this now submarine plain that stretches far away at each side and landward. With other submerged channels of a former land drainage outside our present northern Atlantic coast, as made known by Spencer from the charts of the United States Coast Survey and British Admiralty, and with the equally remarkable submerged river valleys of California traced by Davidson to depths of 2,000 to 5,000 feet in detailed hydrographic work for the U. S. Coast Survey, we have abundant evidence of a high epeirogenic uplift of the greater part of North America. In the Arctic archipelago and along our northern coasts, the preglacial elevation occupied a prolonged period of Late Tertiary and Pleistocene time, permitting erosion of the wide channels which now separate islands and of wide, long, and branching fjords; but southward, on the coast of California and the eastern United States, the less extent of the channels eroded in the now submerged continental slopes, while perhaps proving by the great depths a higher uplift than northward, indicates its shorter duration, as if it were a late stage of geographic extension and culmination of the previously far northern and Arctic elevation. Likewise on the western coast of Europe and Africa great land elevation before the Glacial period is known by fjords and submerged valleys. The continuation of the valley of the river Adour, in the sea bed of the southeast part of the Bay of Biscay, and that of the Congo, are each distinctly traced by soundings to depths exceeding 6,000 feet.

In these epeirogenic movements, very exceptional for their vertical and areal range, as compared with all that we know of the earth's crustal movements in other geologic periods, I recognize the cause of the equally unique Ice age, which closely accompanied the culmination of these uplifts and terminated after the land sank to its present level or lower. Large northern parts of the formerly uplifted lands, both in North America and Europe, having a cold and moist climate, received snowfall during all seasons of the year and became covered by ice-sheets whose borders fluctuated with secularly varying climatic conditions, until depression of the ice-burdened areas brought again warm summers on the borders of the ice-sheets and caused them at last to be melted rapidly away.

From this point of view we see all New England, Long Island, and the country westward, raised in early Pleistocene time about 3,000 feet higher than now, with rivers, as mapped by Shaler, flowing east and northeast from Massachusetts bay and Cape Cod bay, another river flowing east between Cape Cod and Nantucket, another running southward between Nantucket and Martha's Vineyard, and others southwestward from Vineyard sound and Buzzard's bay. When the land attained its maximum elevation, a sheet of ice, fed by the snowfall, overspread the northern half of the continent, excepting Alaska, and reached to an extreme southern limit nearly represented, in its eastern part, by the outer terminal moraine of Long Island, Block island, Martha's Vineyard, and Nantucket. Farther east, I believe that the ice-sheet stretched at one time to the Fishing banks, including George's bank, the Western or Sable Island bank, and the Grand bank of Newfoundland, although inside that boundary the area of the Gulf of St. Lawrence had a driftless, unglaciated tract, partly known to us in the Magdalen islands, while also probably the area now occupied by the Gulf of Maine was the site of a deeply reëntrant angle or sinus of the ice border, between its George's Bank and Nova Scotia lobes. The ice in these latitudes nowhere reached to the sea level during the period of continental uplift. About 3,000 feet below the ice boundary, along the coast as it then was, most of the plant species of our temperate region may have survived and flourished, ready to spread northward again over their former realm as soon as the subsidence of the continent restored there a temperate climate. The return of the flora kept pace closely with the departure of the ice; and thus I think that these islands, as they came to be at the close of the Ice age, received their trees and other plants chiefly from the former lands adjoining them which then were gradually submerged.

It was after the end of the Tertiary era when this region was uplifted to produce the Hudson submarine channel and cañon, and to cause the accumulation of this part of the ice-sheet; for we have preglacial fossiliferous deposits on Gardiner's island, adjoining the east end of Long Island, and in the sea cliff of Sankaty head on Nantucket, including many species, all of which are still living. Likewise, in Massachusetts bay, the same preglacial and warm temperate marine fauna flourished while the sea and land had nearly their present relative levels, as is known by the abundant fragments of shells, representing more than fifty species but including none that has since become extinct, found in the till of the drumlins of Boston harbor and the mainland on the south. These Pleistocene fossils I think to have lived before the beginning of glaciation here, and therefore doubt the inference of Shaler that till was exposed under the Sankaty Head shell beds in the section reported by Desor and Cabot. More probably the continental elevation continued through the Glacial epoch or time of predominant snow and ice accumulation. Its end by subsidence brought the Champlain epoch of glacial retreat, neither interrupted nor followed by any general ice advance.

The Champlain depression of the land is thought by Shaler to have allowed the sea to cover the highest points of Cape Cod and Martha's Vineyard, the land being then at least 300 feet lower than now. But its reëlevation is supposed by him to have been "exceedingly sudden," probably occupying no longer time than a year. He remarks, in the report on Martha's Vineyard, that the absence of wave erosion and shore lines on the marginal moraines and the lower kames and plains indicates that they were not exposed to the action of the sea during even a month. Such rapid rate of epeirogenic uplift, affecting a broad region, appears impossible according to any observed or conjectured relationship of the earth's crust and interior. When I attributed to the differential uplifting of the area of lake Agassiz, between the times of formation of its upper and lower beaches, a maximum rate of about half a foot (or at times one foot or more) yearly, this seemed to me a very surprising and almost unparalleled epeirogenic movement. It is therefore my belief that no sudden and great uplift occurred, but that this region during the Champlain epoch had a somewhat higher level in relation to the sea than at present. The northern depression of the land lower than now I think to have reached no farther southeastward than to the vicinity of Boston. The great subsidence restoring a mild climate and causing the departure of the ice-sheet seems to have brought this region nearly but not quite so low as it is to-day.

Many wide river channels on Long Island, Martha's Vineyard, and Nantucket, extend from the front of the outer moraine belt several miles southward across the declining gravel and sand plains to the sea. Thirty of these remarkable valleys, now dry or in part occupied by small streams, were noted by Elias Lewis, Jr., within a distance of about sixty-five miles on the southern plains of Long Island; and he ascertained that they continue below the present sea level, being traceable beneath the water of the inclosed bays to the beach ridge that divides them from the open ocean. Shaler ascribes such valleys on the New England islands to streams of fresh water issuing from beneath the ice-sheet and continuing in these clearly defined channels of their own erosion several miles onward under the heavy salt water of the sea. Instead I agree with Lewis that the valleys were subaërial courses of drainage from the ice-sheet, showing that the sea at this latitude, when the ice melted back from its farthest limit, did not reach so high upon the land as now.

Tilting and Folding by the Ice-sheet.

During the preglacial period of elevation, rivers flowing along the present beds of Vineyard sound and Buzzard's bay had eroded broad and deep valleys in the soft Tertiary and Cretaceous formations, as the rivers of the same time flowing on the area of Long Island sound had doubtless also done. The ice-sheet then became amassed upon the higher lands at the north and in these valleys, filling and covering them, until even near its southern limit it was hundreds of feet thick. In its slow but mighty outflow the ice-sheet pressed across such transverse valleys against the ridges on their southern side with a force which I believe to have been the cause of the frequently disturbed condition of the incoherent sand and clay beds that there underlie the till and marginal moraines. Very exceptional distortion and folding of these beds are recorded by Merrill, Hollick, Shaler, the present writer, and others, at many places on Staten island, Long island, Gardiner's island, the New England islands, and Cape Cod, coëxtensive with the invasion of the Cretaceous and Tertiary area by the ice-sheet.

All these authors who endeavor to account for this disturbed belt, excepting Shaler, appeal to ice thrust; and I doubt that the grandest exhibition of tilting and folding of these beds in the very interesting and peculiar Tertiary section of Gay

Head, surpasses the wonderful results of glacial thrust on older beds in the islands of Möen and Rügen, in the southwest part of the Baltic sea. Professor Shaler invokes, however, along this whole marginal belt of glaciation, a development of deep faults or folds in the underlying hard rock formations, belonging to the same class as mountain-building movements, and yet finding expression at the surface in disturbances of the clay and sand strata upon narrow tracts, ranging in width from a few rods to a mile, or at intervals across several miles. Except in the Gay Head section, the disturbance generally amounts to no more than a moderate tilting and arching of the beds near the surface or just under drift deposits, with infrequent instances of close folding, and it seems not to extend to great depths. Between these two explanations, I have no hesitation in accepting ice thrust as the disturbing agency in this entire region.

We are led by this view to affirm an extension of the ice-sheet to Martha's Vineyard at an early stage of the Glacial period, long before the deposition of the chief mass of the terminal moraine and other drift there, since Shaler and Woodworth have shown that much erosion and land sculpturing ensued, after the disturbance of the underlying beds, before that main stage of drift deposition. The ice front may indeed have somewhat receded and reädvanced, permitting extensive subaërial erosion, previous to the Champlain depression, final melting, and chief stage of drift deposition. In this connection, it is most important to note that Mr. Woodworth, in a recent letter, tells me that last April he found "glacially scratched pebbles in the boulder beds which occur at the base of the older Pleistocene on Gay Head." After the early tilting and folding, probably many thousands of years passed before the Champlain epoch of low altitude and final departure of the ice-sheet. Within that interval may be comprised the Kansan, Illinoian, Iowan, and early Wisconsin stages of glaciation in the upper Mississippi basin.

Deposits of Modified Drift.

Granitic and gneissic rocks, yielding in decay or in glacial abrasion abundant quartz grains, occupy a very large proportion of New England, far exceeding any other part of the northern United States as to their relative area, in comparison with rock formations yielding principally clay or fine rock flour. It need not surprise us, therefore, when we encounter, adjoining the front of the outermost marginal moraine belts of this region, exceptionally abundant overwashed deposits of gravel and (mostly) sand. These frontal plains reach south from the moraines, with a gentle descent, to the sea. In keeping with this great development of modified drift borne by the waters of rains and glacial melting beyond the ice border, it is equally noteworthy that the outer moraine for a distance of more than seventy-five miles on Long Island, from Roslyn to Napeague, consists almost wholly of massive hills of gravel and sand, with only few boulders or none. So long a section of any terminal moraine built up of modified drift is unknown in the interior of the country, but in some places the same character prevails for a mile or a few miles. Likewise the frontal plains which in this district, on the south side of New England, are grandly displayed along distances of scores of miles, have their analogues for a few miles at many places all along the course of our great system of continental moraines from northern New Jersey to the Dakotas. One tract where I have seen them well developed is along the south side of Devil's lake, in North Dakota. These plains of Long Island and southeastern New England are crossed, as already mentioned, by ancient stream courses which originated during the deposition of the plains, proving this to have taken place, as I maintain, above the sea level.

Earlier gravel, sand, and clay deposits, which are largely represented on the New England islands and the Cape Cod peninsula, named by Shaler, in their order of age from the older to the newer, the Nashaquitsa series, the Barnstable and Tisbury or Weyquosque series, and the Truro series, I think to be all modified drift discharged from the ice-sheet by its superglacial and subglacial streams. Professor Shaler supposes the massive ridges and plateaus of these formations, overspread on the north by glacial drift, to be remnants spared by erosion from an extensive sheet of these deposits that once reached a considerable distance inland with similar thickness. I believe instead that these tracts owed their limits to unmelted portions of the ice-sheet existing on each side at the time of deposition, just as the plateaus of modified drift in southeastern New Hampshire are explained (Geology of N. H., vol. iii, 1878, pp. 155-164, 170-172). Where glacial drift mantles such deposits, as in the very massive Manomet hill, east of Plymouth, I regard the relationship and mode of origin as analogous with the Madison type of drumlins, having a nucleus of modified drift and surface of till (Am. Geologist, vol. xiv, pp. 69-83, with maps and sections, Aug., 1894). The ample development of these series in southeastern New England seems referable, like the later plains in front of the moraines, to the large proportion of gravel and sand in the drift here borne forward by the ice-sheet.

In the lower quarter or third of the thickness of the ice, it appears to have contained drift eroded from the land over which the ice moved; and near the front under ablation at times of glacial recession this englacial drift became superglacial. Its sandy portion was most readily washed away by rains and the water of melting, being deposited partly in great tunnels beneath the ice near its margin, partly in ice cañons and broader channels open to the sky, and also in large part beyond the ice border. The earliest glacial erosion, deriving gravel and sand from alluvium of the Tertiary stream courses, gave many pebbles that are waterworn and superficially decayed, which have plentiful representation in the Nashaquitsa series. The sand grains of these beds and of the Truro series are also often notably decayed. As all these deposits, up to the Truro beds which form the chief mass of the forearm of Cape Cod, have undergone deformations, of the same class as those of Gay Head but far less pronounced, it is apparent to my mind that glacial pressure was efficient to produce these disturbances both at an early stage of glaciation and at a late time near that of the Champlain depression and end of the Ice age.

TILL AND MORAINE BELTS.

Less till was carried to the extreme limit of the ice-sheet than might be expected. Revising his estimate of its average depth in the conspicuous moraine belt on the northwestern hills of Martha's Vineyard, Shaler thinks it no more than 40 feet. In the extended region here considered, the till has less aggregate volume than the modified drift. Farther north, throughout New England in general, I believe that their ratio must be about two or three to one; and in the more thickly drift-covered Northwestern States, it appears to be, on an average, ten or fifteen to one. Nowhere, however, was till carried in great volume to the boundary of glaciation. It seems to have been borne forward as material scattered through the slowly flowing lower part of the ice-sheet, mostly transported only a few miles, but including, especially in the marginal moraines, many boulders carried higher into the ice than the chief part of the drift. The middle and upper parts of the ice-sheet moved much faster than its friction-hindered and drift-laden lower portion; hence marginal moraines have usually more boulders, and more drift derived from great distances, than the general sheet of till.

Professor Shaler argues that the moraine belts of the New England islands and Cape Cod, occurring mainly on high tracts, were formed by an attenuated border of the ice-sheet, here so thin that it floated on the sea over valleys, while yet remaining as a united mass, and beyond was grounded upon the ridges, depositing the morainic drift. Westward, however, we cannot doubt that the same marginal drift continues on the sea bed between Martha's Vineyard and Block island, and thence to Long Island. The belts sweep in similar lobate and concentrically curving course as in the interior of the country. Therefore I think, after noting the courses of the two chief belts, the outermost on Martha's Vineyard and Nantucket, and the second on the Elizabeth islands and Cape Cod, that the ice-sheet at the times of their formation reached far onward to the east, on the adjoining shoals and the more distant George's fishing bank. As before stated, the sea, according to my opinion, then covered less of the continental border in this latitude than now, the shoals and fishing bank having been very probably land areas when the ice finally retreated.

DURATION OF THE QUATERNARY ERA.

From the supposed deposition and ensuing erosion of very extensive sand deposits upon a great area of southeastern Massachusetts, since the Tertiary era, Shaler estimates the Quaternary era to have comprised not less than a million years. The escarpment boundaries of portions of these sand deposits, thought by Shaler to be remnants of erosion, I ascribe to barriers of unmelted tracts of ice, towering high above the sand ridges and plateaus at their time of formation, but leaving them surrounded by low areas when the ice-sheet was fully melted. Therefore no geologically vast lapse of time is required, according to my view, for the post-Tertiary history. Probably a hundred thousand years for all the period of land uplift, glaciation, subsidence, departure of the ice, and subsequent duration to the present day, would be nearer the truth. At least, such would be my estimate from a survey of the early Quaternary and Glacial records thus far known on this continent; and a nearly similar conclusion seems to be reasonably drawn from the Quaternary history of Europe.

The well known physical researches of Lord Kelvin, Clarence King, and others, concerning the age of the earth as an abode of life, and the geological estimates and computations of Dana, Walcott, Reade, and others, indicate that no more than a hundred million years, or perhaps only thirty million years, more or less, have sufficed for all the life history of our globe. With this measure we find no decided disagreement, if the Quaternary era has occupied only about a tenth part of a million years; but a much larger estimate for this era would imply, by application of reliable ratios for the preceding geologic eras, a far longer duration of the earth. There is a solidarity of all truth, and when a part becomes discordant through inferences from unproved theories, it may be taken as a suggestion that the theories are probably erroneous and need revision.

Bibliographic References.

Without attempting to give a complete list of all papers bearing on the Quaternary geology of this peninsular and island district, it will yet be serviceable, for further investigation of the questions here considered, to cite as follows, in alphabetic order of authors and chronologic sequence of their writings, a large part of this literature, which mainly receives in Prof. Shaler's several papers very scanty discussion or mention.

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NOTICE OF A NEW DISCOVERY CONCERNING UINTACRINUS.

By Frank Springer, Las Vegas, New Mexico.

Some recently acquired material from the Niobrara Chalk has disclosed a new and remarkable fact about this interesting fossil. The genus *Uintacrinus* has been hitherto described as possessing, below the radials, a single circlet of basals surrounding an undivided pentagon; this pentagon has been supposed to represent either the coalesced infrabasals, the proximal or terminal stem ossicle, or a mere supplemental plate developed to fill up the space left by the disappearance of the stem. It is now ascertained that the above structure, although frequent, is not a uniform characteristic of the genus. Some of the specimens have below the basals a ring of five infrabasals, and these in turn enclose the undivided pantagon, or centrale,—thus giving the basal structure of *Marsupites.* In this form the centrale cannot represent coalesced infrabasals, for these are also present and surround it. Wachsmuth and Springer's law of the orientation of the parts below the radials prevails here: the infrabasals are radial, while the centrale is interradial when the former are present, and radial when they are not,—just as the stem should be. We have here, therefore, the two distinct types of base, monocyclic and dicyclic; and, what is most extraordinary, they occur among individuals not only of the same genus, but apparently of the same species *U. socialis.*

My purpose in this note is merely to record the fact, which will raise some interesting questions touching classification. The proof of it, with sufficient details and illustration, will be given in a paper now in preparation.

THE EVOLUTION OF CLIMATES.*

By Marsden Manson.

Chapter I.

The Fundamental Problem.

Since geology reached the initial stages of a science, attempts to accurately trace the history of the earth back into the infinite past have been hampered at the very outset by unsolved problems.

The first of these problems is embraced in the question—What was the cause of the Ice age? Back of it lie others of a kindred nature, for there is as yet no satisfactory and accepted cause assigned for the universally temperate climates of the early Quaternary and late Tertiary periods; nor for the universally tropical climates of the Mesozoic age; nor yet again for the torrid climates existing from pole to pole during the Palæozoic ages. In each of these grand divisions of geological time, glacial phenomena occurred which still further complicate these general problems.

Confronting us there are also unsolved problems as to how the present climates were inaugurated at the close of the Ice age, and regarding the conditions towards which present climatic developments are tending.

Closely linked with these problems are questions touching the stages reached in the climatic development of planets which are apparently further, and of planets which are apparently less advanced than the earth: for, whatever may have been the dates and modes of their origin, differences in mass, distance and surroundings have varied the rate of development of each. At any particular period progress has not been the same for all, and we find each one in that particular stage which its mass, environment and exposure have permitted it to reach; yet all are governed by the same general laws and must be progressing toward the same general condition.*

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*The views expressed in this paper have in part appeared in the following desultory articles:

The Cause of the Ice Age and an Explanation of Geological Climates. Proc. Technical Soc. Pacific Coast, Sept., 1891.

Geological and Solar Climates. Their Causes and Variations. A Thesis in Geology and Physics. University Cal., May, 1893.

Circulation of the Atmosphere of Planets. Transactions, Technical Soc. Pacific Coast. Vol. IX, No. 5, Jan., 1892. Reprinted Astronomical Soc. Pacific Coast.

The Cosmic Character of the Ice Age. Glacialists' Magazine, Vol. II, Nos. 5 and 6.

The Cause of the Ice Age and of Geological Climates. Trans. Geol. Soc. Australasia. Vol. I, Part VI.

These papers, like the present one, are the result of work during spare moments from professional work in other lines. To co-workers, no other apology is necessary.

The first problem in the series has attracted not only the geologist, but the astronomer. The mathematician, undismayed by lack of data or lack of a fulcrum on which to rest his powerful analytical lever, and aided mainly by hypothesis and assumption, has striven to limit or extend the lines of study. Awed by the intricacy and apparent accuracy of his calculations, and fearing to attack his data, others have been led into error; and thus the attempts to apply the most accurate branch of science to these questions have occasionally thwarted the advance of knowledge.

The problem is a complicated one; in its solution the laws of physics must be rigidly followed and the geological record of the climatic changes which the earth has passed through must be correctly interpreted. The conditions which admit of the seasonal melting off of the polar snow caps of Mars on the one hand, and the clouded atmosphere of Jupiter on the other, must yield confirmatory evidence.

Fortunately the elementary principles, the premises upon which the argument must be based are fundamental in their character and are generally admitted to be true. But before going further it is necessary to clear the field of certain fallacies. This can best be done by a short review of the principal attempts which have been made to solve the problem, and by a presentation of the conclusions which the master minds of geology have reached.

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*This, so far as the author has been enabled to investigate, is not true of satellites; for they seem to have been deprived of all volatile matter, and therefore have been and are exposed to very different conditions of radiation and reception of heat, as compared with planets.

The author believes that it is demonstrable that if a planetary mass equivalent to the combined masses of the earth and the moon be differentiated by any process into the two existing masses, the larger mass must retain all volatile matter; also that where the attraction between two masses is sufficiently great to turn the smaller mass with its denser portion toward the larger and hold it in this position without independent axial revolution, the larger mass will attract and retain all volatile or gaseous matter.

Chapter II.

Review of the Principal Theories which have been advanced to account for Glacial Epochs.

Views of Eminent Geologists. It would not be instructive to attempt to review all of the theories which have been urged, as some writers have ascribed remote, inadequate or obscure causes, and others resorted to hypotheses beyond the range of either analysis or investigation; therefore, only the leading causes will be briefly mentioned.*

1.—A decrease in the original heat of the globe.

2.—Changes in the elevation of land, and consequent variations in the distribution of land and water.

3.—Changes in the obliquity of the axis of the earth.

4. A period of greater moisture in the atmosphere.

5.—Variations in the amount of heat radiated by the sun.

6.—A variation in the heat absorbing power of the sun's atmosphere.

7.—Variations in the temperature of space.

8.—A coincidence of an aphelion winter with a period of maximum eccentricity of the earth's orbit.

9.—A combination of 8 and 2.

10.—The views of Sir Robert Ball, LL. D., etc., as expressed in his recent work, "The Cause of an Ice Age,"† Chapters 5 and 6.‡

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*See also the Climate Controversy, S. V. Wood, Jr., Geol. Mag., 1876 and 1883. Climate and Time, Climate and Cosmology, James Croll; Island Life, Alfred Russell Wallace, F. R. S. etc. Philosophical Magazine, May, 1864. British Association Reports, part 2, p. 11, 1876. Proceedings Royal Soc., vol. XXVIII, p. 15. Quart. Jour. Geological Soc., Feb. 1878; Nature, July 4, 1878; Trans. Geological Soc. Glasgow, Feb. 22, 1877; The Ice Age in North America, Dr. Fred. G. Wright, Appendix by Prof. Warren Upham; Révolutions de la Mer. Deluges Périodiques, Alphonse Joseph Adhémar. Report Brit. Ass'n. 1892, p. 708, J. W. Gray, F. R. S. and Percy F. Kendall, F. R. S.; The Cause of an Ice Age, Dr. Sir Robert Ball; The Great Ice Age, Ed. of 1894, Chap. XLIII. Prof. Dr. Geikie.

†See also The Date of the Last Glacial Epoch. Gen. Drayson, R. A. Science, Nov. 25, 1892.

‡The tenth is not properly a theory to account for the Ice age, but rather a demonstration of a particular problem by Dr. Ball, F. R. S., etc., to the effect that 63 per cent. of the solar heat reaches either hemisphere during its summer exposure, and the remaining 37 per cent. during winter exposure. Nothing is added to the Physical Theory of Dr. Croll, nor does the demonstration in any way remove the objections which have been urged against Dr. Croll's views.

1. A Decrease in the Original Heat of the Globe.

The first of these theories is universally admitted, and taught in even elementary works on physical geography, but it fails to account for all the phenomena accompanying the Ice age, or to account for the disappearance of that age, and, so far as the author is aware, has not been presented in such form as to satisfactorily account for "geological" and present climates in rigid conformity with the facts and known laws. Nor has it been presented in such form as to account for the occurrence of glacial phenomena during each of the great eras of geological time; nor again does this theory present any mode of accounting for the rise in temperature since the culmination of the Ice age.

The idea that the earth was, at an early period of its history, a heated mass is recognized and admitted by nearly all physicists. Some of the earlier geologists have attempted to account for the climatic changes which are recorded by fossil life upon the basis that the gradual cooling of the globe was the cause of these changes in temperature.

But the complications introduced by the announcement that the earth has passed through an Ice age, and the interpretation of ice action in earlier ages into proofs of "glacial periods", have caused most geologists to abandon this view. How thorough this abandonment has beeen can be seen from the following quotations:

"It is evident that the idea of connecting the phenomena "of the internal heat of the globe with terrestrial climates, "whether of the present or of the past geological ages, must "be entirely abandoned, as it has been by most writers on this "subject. The hypothesis cannot be allowed to stand as even "one of the possible theories of climatic change."*

"In fact is seems almost certain that during the whole re-"corded history of the earth, i. e., during the time that it has "been inhabited by organisms, the surface temperature of the "earth has been almost wholly due to external causes."†

"The first theory brought forward to account for glacia-"tion, was that the earth having been originally in a fiery state,

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*Whitney—The Climatic Changes of Later Geological Times.

†Le Conte—Elements of Geology; p. 381. Third Edition, N. Y., 1891.

"has in cooling passed from a condition of universal warmth "to a more and more frigid state until the present conditions "were attained. This is the least tenable of all theories, for it "neglected the now evident fact that there had been changes "from cold to warmth and back again to cold. However, as it "was invented before the existence of glacial periods was suspected, it long commanded a general assent and was the "opinion that held the ground until near the middle of this "century."*

2. *Changes in the Elevation of Land and Consequent Variations in the Distribution of Land and Water.*

The second theory may be accepted as a local and correlated phenomenon, but cannot be accepted as a primary cause, since glaciation did not depend solely in the same latitudes upon elevations above sea level: besides the changes of temperature in the ocean—although more gradual—were quite as marked as those upon the land. Of this upheaval and depression hypothesis, Dr. Jas. Geikie very properly remarks: "It is true that many movements of depression and elevation "occurred during the glacial period, but none of these was on "the great scale required by this hypothesis. Further, we may "admit that a causal connection probably obtained between "these movements and glaciation. Elevation, however, did "not bring about general glaciation, but the latter was perhaps "the cause of depression, for with the disappearance of glacial "conditions, the sunken areas rose again.†

There is, however, an able and earnest school of geologists,‡ the members of which, following the ingenious arguments and explanations of Sir Charles Lyell and Prof. Jas. D. Dana, find a cause for glaciation in the upheavals and depressions occurring during the Quaternary.

Submarine Channels as Evidences of Upheaval and Depression. In many of the attempts to prove that upheavals were the prime cause of glacial conditions, there are facts brought forward to show that submarine channel-like depressions exist adjacent to the mouths of many rivers.* It is argued that these channels are the result of erosion, which erosion could not have occurred unless the land stood at a greater level than at present; and that, as these channels are now submerged, the land must have sunk since the erosion. This argument is plausible, and has been presented with such force by high authorities that these "submarine channels" are frequently accepted as absolute proofs of an upheaval of the adjacent land areas, of a period of glacial and other erosion, and of a subsidence to the present conditions.

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*Shaler & Davis—Glaciers; p. 70.

†The Great Ice Age, p. 790 (Ed. 1894).

‡The Epeirogenic Theory of the Causes of the Ice Age.—Prof. Warren Upham. Glacialists' Magazine, Vol. I, No. 10, May, 1894. p. 211, et seq.

But the existence of submarine valleys is not always proper evidence that they are the result of erosion during a previous era of upheaval. Channel building by bank elevation is a process of sedimentation which goes on under water as well as, or better than, under air,† so that the existence of nearly parallel banks on either side of the lines of discharge of the St. Lawrence, Congo, or other rivers, is not proper evidence that the adjacent lands were at one time elevated to a hight equal to, or greater, than their present submergence.

Before a submarine valley shall be decided to be one of erosion, its form should be shown to correspond to proper lines, and the eroded material should be accounted for as a bar at the submarine mouth.

The sediment which these rivers have borne to the ocean during their entire existence must have been deposited more upon the flanks of the outflowing fresh water, than in the direct lines of swiftest flow. If one will take the pains to plat to natural scale the sections of some of these submarine channels and banks, he will find that the banks correspond more nearly to those of sedimentation.

These submarine banks may therefore be evidence of the permanence of the existing levels of land and water, rather than evidences of fluctuations in these levels.

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*The Epeirogenic Theory of the Causes of the Ice Age. Prof. Warren Upham, F. G. S. A. The Glacialists' Magazine, Vol. I., No. 10, pp. 211-217. Also Am. Geologist, Vol. VI, Dec. 1890, No. 6.

†See pp. 2,521-2,522, Appendix M. M., Report of Chief of Engineers, U.S. A. 1882, or Ex. Doc. No. 93, 46 Congress, 3rd Session, p. 718. In these reports the actual building up of the banks of such channels is shown to have been accomplished in less than one-half a century.

3. *Changes in the Obliquity of the Axis of the Earth.*

While slight changes in obliquity have occurred, and must continue to occur, the results are too slight and the distribution of glacial phenomena is too general to warrant the acceptance of such change as a prime cause.*

Of this view lord Kelvin says, "There is in fact no evidence in geological climate throughout those parts of the world which geological investigation has reached, to give any indication of the poles having been anywhere but where they are, at any period of geological time."†

4. *A Period of Greater Moisture in the Atmosphere.*

That earlier ages were characterized by a more abundant distribution of moisture than now prevails cannot well be controverted. But a glacial period is not only dependent upon evaporation but also upon temperatures sufficiently low to cause condensation in the form of snow and to conserve this over long periods. Warm seas with an abundant evaporation and cold continental areas must have been the characteristic conditions at the inauguration of the Ice age, but there is every reason to conclude that at the culmination of that age the seas were intensely cold and consequently that evaporation was reduced to a minimum.

The assignment of a period of greater moisture in the air as a cause, appears to be attaching too great importance to one of the conditions prevailing at the inauguration of the Ice age. The author will endeavor later on to make this more apparent.

5. *Variations in the Amount of Heat Radiated by the Sun.*

6. *A Variation in the Heat-absorbing Power of the Sun's Atmosphere.*

7. *Variations in the Temperature of Space.*

These are hypotheses resting on insufficient data.

8. *A Coincidence of an Aphelion Winter with a Period of Maximum Eccentricity of the Earth's Orbit.*

The eighth theory has been presented to the scientific world through the labors and researches of the eminent geologist and physicist, Dr. James Croll, in his various articles in leading scientific magazines, and lastly, in his notable contributions to the subject under discussion, "Climate and Time," and "Climate and Cosmology."

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*The Great Ice Age, Ed. 1894, p. 794. See also note on same page.

†Popular Lectures and Addresses, Vol. II. p. 298. See also Brit. Assn. Report 1876. Part II, p. 11. Prof. Geo. Darwin; Trans. Royal Soc., Vol. 167, pp. 271-312.

The scope of study and the ingenuity of presentation of Dr. Croll's views are models—yet scientists cannot accept his conclusions.

Dr. Geo. F. Becker has presented a mathematical discussion of the physics of Dr. Croll's theory and presents the following opinion. "It seems to me, then, that the period of the greatest eccentricity would be most unfavorable to glaciation, the snow-fall being the smallest, and the summer rainfall the largest which can occur with the present obliquity."*

Later in the same paper Dr. Becker leans somewhat towards the views of Dr. Wallace. "I feel compelled to assert that the combination of *low eccentricity and high obliquity* will promote the accumulation of glacial ice in high latitudes more than any other set of circumstances pertaining to the earth's orbit. It seems to me that the glacial period may be due to these conditions in combination with a favorable disposition of land and water."†

Dr. Jas. Geikie, after his exhaustive review of the principal hypotheses which have been brought forward, says:

"The primary cause of these remarkable changes is thus an extremely perplexing question, and it must be confessed that a complete solution of the problem has not been found. Croll's theory has undoubtedly thrown a flood of light upon our difficulties and it may be that some modification of his views will eventually clear up the mystery. But for the present, we must be content to work and wait."‡

This view is also applicable to the views of Dr. Wallace.

Dr. T. G. Bonney, in an interesting discussion of this subject, remarks:

"The extension of the glaciers on Mt. Kenya, 19,500 feet, is specially interesting, because its position (almost on the equator) suggests a possible refrigeration of the earth as a whole rather than of its hemisphere independently."*

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*Certain Astronomical Conditions Favorable to Glaciation. Am. Jour. Sci., Vol. XLVIII (1894), p. 106.

†Ib. p. 107.

‡The Great Ice Age, 3rd Edition, p. 816.

This conclusion applies also to all evidences of glacial action in sub-tropical and tropical latitudes.

9. A Combination of (8) A Coincidence of an Aphelion Winter with a Period of Maximum Eccentricity, and (2) Changes in the Elevation of Land and Consequent Variations in the Distribution of Land and Water.

The ninth theory has been maintained by one of the greatest English naturalists, Dr. Alfred Russell Wallace. He combines the theory of Dr. Croll with that of Sir Charles Lyell, and very ably presents his views in "Island Life."

The strongest support that has been given to any of the foregoing theories is contributed by the arguments and deductions of Dr. Croll and Dr. Wallace; yet they have failed to effect conviction for, in a recent work, Dr. Joseph LeConte, after reviewing the various theories as to the cause of the Ice age, uses this expression: "This seems to be by far the most probable yet presented."†

With a full knowledge of the general and special literature on the subject and after a comprehensive review Dr. T. G. Bonney says:

"It follows from what has been said above, that the low temperature which undoubtedly prevailed during the Glacial epoch has not yet received any satisfactory explanation.

Each one that has been proposed is either inadequate or attended by grave difficulties. It is therefore probable that some factor which is essential for the complete solution of the problem is as yet undiscovered, *or at any rate, the importance of one which is already known has not been duly recognized.*"‡

Dr. Jas. Geikie, after summing up all the evidence and reviewing all the theories, admits that no satisfactory solution has been offered:

"Geologists are justly jealous of attempts to account for the facts of their science by reference to causes other than those they see at work in the world around them. And perhaps the frequent failure of physicists and astronomers to frame a satisfactory theory for grand changes of climate may sometimes have been viewed by geologists with a kind of secret satisfaction.

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*Ice Work, Present and Past, p. 242. Appleton's, 1896.

†Elements of Geology, 2nd Edition. page 578.

‡Ice Work, Present and Past, p. 260. (Appleton's 1896). Italicised by the present writer.

"It seems likely, however, that in this matter they must, after all, be content to follow the guidance of the astronomer and physicist, seeing that their own science refuses, in this particular at least, to yield as much assistance as would be desirable. Nor, after he has sufficiently questioned all the natural causes with which his own peculiar studies have made him familiar, ought the geologist to feel surprised that these sometimes fail to explain the phenomena that come under his cognizance. There is no hard and fast line separating the domain of one science from that of another, and as the circle of knowledge enlarges boundary divisions become more and more difficult to determine. Perhaps of no science is this more true than that of geology. At one time the investigator into the past history of our globe had the field almost entirely to himself, and the limits of his study were as sharply defined as if they had been staked off and measured. Now, however, it would be hard to say on which of the territories of his scientific neighbors he must trespass most. He cannot proceed far in any direction without coming in contact with some worker from adjacent fields. His studies are constantly overlapping those of the sister sciences, just as these in turn overlap his. It will, therefore, only be a further proof of the unity of nature if those intricate problems which have hitherto baffled the geologist should eventually be solved by the researches of astronomers and the conclusions of physicists."*

Chapter III.

The Scope of the Problem.

From the review made in the preceding chapter, and from the quotations given, we see that it cannot be said that there exist opposing schools of geologists advocating with any degree of unanimity any special interpretation of, or assigned cause for, past climatic variations.

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*The Great Ice Age, 3rd Edition, pp. 794-5.

The most distinguished scientists who have investigated this subject, have no considerable number of followers; and equally distinguished co-workers accept in part only, or reject entirely, the conclusions reached by their fellows.

The most conservative and deeply read scholars express themselves in the doubtful and cautious terms just quoted, or admit that they "must be content to work and wait."

The disagreements as to cause, extend also to actual facts and phenomena, and we find geologists of high repute disagreeing as to whether certain phenomena, existing in warm temperate and tropical latitudes be glacial or not. Nor is this disagreement that which usually appertains to the nebulous and debatable fields of all branches of science, but it is fundamental. It relates to the very principles upon which the sciences of geology and physical geography rest.

Confusion is also introduced through lack of uniformity in the terms used; the period of maximum glacial extension is spoken of as the Ice age, the great Ice age, the Glacial period, the last Glacial epoch, etc.

The use of the adjective great suggests that there have been other ice ages; and the term last glacial epoch, suggests others of a series.

It is not possible in the present stage of the question to frame a definition which would give general satisfaction—that is, a definition which would reasonably fix the time limits of the Ice age. It is probable that ice has had a periodical and variable existence upon restricted areas throughout the greater portion of geological time. In a broad sense, therefore, this age embraces that period of the world's history during which ice has been a geological agent; it would embrace the earlier geological ages, during which ice formed on elevated peaks; the Carboniferous and Permian eras during which ice sheets became quite extensive; the Quaternary period during which glacial conditions reached a maximum; and the present era during which polar regions and mountains above the snow line are yet subjected to ice action.

As ordinarily understood and used by geologists the terms Ice age, Glacial period, and Glacial epoch are synonymous and embrace an indefinite period of time between the early Quaternary and the present era, during which glacial conditions were more extended than at any other period. The author would define the beginning of the Ice age to be that period when the oceans ceased to receive heat from the bottom, and began to accumulate water at its maximum density; the culmination of that age to be that period when solar heat began to permanently remove glacial conditions and to establish its control of surface temperatures. It is reasonably certain that glacial conditions were first removed from the torrid zone. It is probable that maximum glaciation along the belt of maximum precipitation in the northern hemisphere about lat. 50° occurred subsequent to the culmination of the Ice age, and that maximum glaciation of polar regions occurred at a still later period. Thus glacial conditions may have been cumulative upon successive portions of the globe. The Ice age has long since terminated in tropical regions, more recently in temperate latitudes and yet remains within the polar circles; from which the present indications, as interpreted by the author, are that it is destined to disappear and be replaced by polar snow caps, which, like those of Mars, form and melt away with the seasons.

In the present condition of science the student is not offered a logical explanation of climatic evolution; but instead, is presented with a mass of facts, which are interpreted along various lines and seem to warrant some writers in the conclusion that in the evolution of climates, there have "been changes from cold to warmth and back again to cold." This whilst true in a restricted sense is not so broad as to include the recurrence of general glaciations, or successive glacial epochs.

With a vast array of facts at command—with a remarkably intimate knowledge of past life-conditions, there has nevertheless been recorded a complete failure to arrive at satisfactory conclusions as to the cause of the secular variations in climate which have marked geological history. Such failure results from the introduction of radical errors, from the omission of fundamental principles, or from a misconception of the character of the problem. When any one, or any combination of these misleading factors, is permitted to enter into so complicated a problem, the human mind, although yearning for truth, often strays far from it, and resorts to suppositions and hypotheses which cannot be established. The stronger and more acute the intellect, the farther will it be tempted to wander into these bewildering fields, and the more enticing become the witcheries of the "philosophy of assumption."

The adage, "false in one, false in all," was never more justly applied than it might be to many arguments presented to account for the series of climates terminating in the Ice age, and ushering in the dawn of the solar climates now ranged in zones about our planet, and evidently different from the climates preceding the Ice age.

An explanation which will admit of definite proof, and will satisfy all the conditions, and not require the distortion of known facts, by forcibly fitting them into arbitrary molds, will receive universal acceptance. It must start from generally admitted premises, and in rigid consonance with known laws, interpret the grand eras of climate which have marked the geological history of our globe; it must point out and fully elucidate wherein and why the present climates of our globe differ so radically from those secular variations recorded by fossil life; it must explain how present climates were developed from the previous state, and correctly set forth the conditions towards which this development is now tending.

Uncertainty and doubt will be removed only when the Ice age, the widespread temperate conditions preceding it, and the universally tropical climate of the Mesozoic and Paleozoic eras, are all explained by logical deductions from universally accepted premises and laws. Glacial phenomena, occurring at any latitude and during any period of geological time, must be shown to be the result of the same laws which have controlled climatic development.

Should there be planets whose conditions apparently indicate a less advanced period of climatic development than the earth is now in, the geological history of the earth if correctly interpreted would show that the earth has passed through the conditions now prevalent upon the younger planet. If, again, there be planets whose size and observed conditions seemingly mark a greater progress and development than the earth now enjoys, the interpretation of the laws now acting should be such as to indicate that the earth's developments are tending towards those prevailing upon the older planet. Thus the two sciences of geology and astronomy must agree in the solution of the problem, and each must add its store of observed facts to clear away the mysteries which have obscured the truth.

Chapter IV.

Epitome of Past Climatic Variations.

The record left by the last of the series of climates through which the earth has passed is the evidence upon which geologists have established the existence of the Ice age.

To speak of the Ice age as a past epoch in the earth's history is not quite correct. Over the greater part of polar latitudes this age is yet in existence at all altitudes; in temperate latitudes, the area over which its present existence extends are more restricted and are confined to elevations between 5,000 and 15,000 feet according to latitudes; in the tropical zone a still greater restriction as to area and altitude exists, glaciers being found only at hights above sea level approximating 16,000 to 20,000 feet. It is therefore possible to speak of it as a past age only in a somewhat restricted sense; and the evidence of progressive retreat found at the base of existing glaciers justifies the opinion that it is a passing age.

From the strata of each of the geological ages, and almost from those of each period, evidence has been found of ice action.* This evidence is so widely distributed and has been identified with such a degree of certainty in some instances that it must be accepted as proof that ice has been an agent from the earliest geological ages. Whatever may be the doubt or obscurity attaching to some of these evidences of ice action, it must be admitted that during each age from the Palæozoic to the present, glacier ice has formed and has recorded and is recording its existence in a legible and characteristic manner.

We must therefore conclude that the glacier was an early agent in geology, and that elevated areas were as liable to be glaciated in pre-Quaternary time as they are now. We must admit and weigh all the evidence regarding these glacier marks, and solve the problems of climatic evolution without omitting or ignoring this evidence. At the same time, it will not do to build up an ice age on insufficient data. Glacier ice is in existence now in both torrid and temperate latitudes, and is recording the evidence of its action in the same manner as heretofore, but it is not accompanied by corroborative evidence. It is not therefore permissible to advance the theory of a present ice age over tropical and temperate latitudes. If present glacial action in these latitudes descended to sea level and were it accompanied by marine life of arctic types, and were temperate and tropical forms absent, the existence of a glacial period would be established, but glacial action alone is not sufficient evidence upon which to base the occurrence of a glacial period. We should be cautious, therefore, in building up a glacial period upon insufficient data in any geological age.

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*Oldham, Geol. Mag., Vol. XXIII, 1886. White, Am. Geologist, Vol. III, 1889, pp. 222-230.

The Relation of Present Glaciers to the Problem.

Wherever within tropical or temperate areas glaciers yet rest, they are at once recognized as the feeble remnants of once vaster extensions.* Therefore at the outset is established the fact that glacial conditions have been much more extensive than at present and that they are yet retiring. Consequently there confronts us at once the problem of accounting for this past extension and present retreat. The student may start at the base of the great Malaspina glacier of Alaska, lat. 60° N., and follow the evidences of past glacial action into the tropical regions, through the just uncovered pleateaux, fiords, and mountains of British Columbia, lat 50°; through the yet earlier uncovered and fainter traces in the Sierra and Coast range of California, lat 42° to 35°; through Mexico, lat 30° to 15°; even with Belt and Crawford, through the barely traceable markings of Nicaraguan glaciers, in lat. 12° to 8° N.

Starting at the confines of the south frigid zone the same gradations of distinctness in glacial markings can be traced northwards, until they fade in the highly modified and indistinct evidences within the tropics.

Again, the student may ascend 16,000 to 20,000 feet above the level of the sea in the Equadorian Andes, or upon Mt. Kenia in equatorial Africa, among the dwarfed remnants of actual glaciers doing their work under the same laws as those of Greenland, and from these hights trace the evidences of their work as they grow fainter and older, until they fade into the transformed drift of the tropical plains below. At all temperate latitudes where glaciers exist the same gradations of distinctness can be traced in descending to sea level; and as at each latitude and at all altitudes the existing glaciers are so far as known yet retreating, this retreat must be accounted for by known laws now active.*

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*Prof. I. C. Russell, Am. Geol., Vol. IX, No. 5, May, 1892. In addition to the extended list of authorities cited by Prof. Russell see also the article by Prof. Dufour, Bulletin Soc. Vaud. Sc. Nat., Vol. XVII, 1891, pp. 422-425; Report Brit. Assn., 1881, p. 742; "Life of Agassiz," Vol. II, pp. 717-729, also pp. 743-747. The Great Ice Age, p. 711 et seq. pp. 721-2 (3rd Edition Re-written), Dr. James Geikie, New York, 1895.

Below the altitudes at which glaciers are now found in temperate and tropical regions exist evidences of greater extension. The distinctness of these evidences varies inversely as the mean annual temperature of the localities in which they occur; that is, the farther either in latitude or altitude the evidence of past glacial action is from existing glaciers the fainter and more modified is the evidence. This marks a progressive retreat from tropical to polar regions and from sea level upward.

As this retreat is yet in progress, as has been observed at all known glaciers, it is apparent that at the present time the Ice age is yet passing away, and that it yet remains upon a considerable portion of the earth; it is strictly a past age only for the great temperate and tropical portions of the globe and even in these it is in existence at considerable altitudes above sea level; the ultimate limit of the effect of solar energy in modifying the conditions of the Ice age has therefore not yet been reached, for the progress of this effect is not only noted by the geological and physical tracings of the vast glacial retreat but by the observed progressiveness of this retreat.

The evidence relied upon to establish the existence of glacial periods consists in:

1. Forms of life suitable only to arctic or boreal temperatures, and particularly marine life of this character.

2. Types of topography shaped only by the action of ice; and built up of irregular, semi-stratified clays, sands, gravels, and sub-angular and rounded boulders.

3. Moraines marking the final or temporary limits of gla-

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*See authorities just quoted.

cial dispersion (a) from belts of maximum precipitation and (b) from elevated lands down the slopes of which glaciers flowed.

4. Striated and polished surfaces of either rock in place or of detached masses.

5. A surface distribution of "erratics" or large and small masses of rock transported only by flowing ice, and marking the direction or limits of flow.

Of these the first may properly be said to be the only absolute and confirmatory proof of an ice age. Any or all of the others might have been formed during any stage of the earth's geological history, provided land areas were sufficiently elevated to permit of the local formation of glaciers. The evidences mentioned under (4) and (5) have actually been observed at many localities,* and at widely separated latitudes, in which latitudes tropical forms of life were co-existent. The only period in geological history, in which all the distinctive and characteristic proofs of an ice age occur is in Quaternary times. One of the marked characteristics of these proofs is that everywhere they just ante-date the present era. The true meaning of these evidences was first developed in cold temperate latitudes.† The disputes on the subject were very animated and sometimes bitter during the few decades subsequent to the announcements of Agassiz of his belief in the existence of an Ice age.

The contests over the evidences of Quaternary glaciation were then shifted to that occurring in warm temperate latitudes‡ and are now confined to that in tropical latitudes.§

It is gratifying to the searcher for truth that this gradual progress has been made and that each step has been contested, for the naked truth would at any of the earlier stages of scientific development have been received with incredulity.

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*Oldham, Geological Magazine, Vol. XXIII, 1896.
White, Carboniferous Glaciation, Am. Geologist, Vol. III, 1889, pp. 229-330.
See also Glacialists' Mag., Vol. I, No. 6, p. 143, and authorities there cited. Also the extensive lists of instances cited by Oldham & White.

†Switzerland, Germany, France, North American States.

‡ Gibraltar, Palestine, North Africa, India, Chile, Australia, New Zealand, etc.

§South America, Central Africa, Tropical Islands. See Journal of Geol., Vol. I, No. 8, pp. 752-772. Glacialists' Mag. , Vol. II, Nos. 5 and 6, pp. 90-114.

It was long held and is probably now held by the great majority of geologists, that as glacial retreat in the northern hemisphere has been toward the pole, glacial deposition was from that direction, and that glacier ice has never invaded latitudes as near the equator as 37°; yet Dr. Geikie cites glacial action at sea level at Gibraltar,* and Agassiz cites corresponding action at 37° S.† and a number of observers cite evidences of ice action adjacent to or within the tropics.‡

The facts establishing the comparatively recent glaciation of both cold temperate and warm temperate latitudes were refused credence and ridiculed in but recent years; it is therefore to be expected that the more modified and fainter evidences within the tropics should be strongly wrangled over; it is well that they should be.

Upon Mt. Kenia in 1° S.§ and in other equatorial African mountains and peaks, and in the EquadorianAndes|| the shrunken remnants of vast glaciers yet rest; just below these tropical glaciers are evidences of recent retreat, and still further the evidences fade gradually into the tropical growths of the plains at the bases of these mountains.

Tropical Glaciation.

The controversies between geologists regarding glacial extent during the Ice age have thus shifted in the past few decades from temperate to tropical areas.

There are admitted difficulties in tracing and differentiating

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*The Great Ice Age, 3rd Edit. 1894-95, p. 598.

†A Journey in Brazil, page 427, note.

‡Hartt, Physical Geography & Geology of Brazil; Belt, The Naturalist in Nicaragua; De La Beche, Trans. Geol. Soc. London, Vol. 2, Second Series, pp. 182-186; Blanford, Quart. Journal Geol. Soc., London, Vol. X, 1841, pp. 159-267.

Chardin, Travels in Persia, (Pinkerton's) Vol. IX, p. 178; Crawford Am. Geologist, Vol. 8, Nov. 1891, No. 5, pp. 306-314. On the Coast of China around Amoy in Lat. 24° N. evidences of glacial action are full and complete.

U. S. Special Consular Reports, Streets and Highways.

Dep't of State 1891, pp. 520-525.

Nicaragua, Report U. S. Commission (Ludlow), page 15.

§G. F. Scott-Elliott. Quart. Journ. Geol. Soc., Vol. LI, No. 204, pp. 675-6.

||Whymper. Travels among the great Andes of the Equator, p. 62, note I.

the action of geological forces in tropical areas, which is due to the earlier removal of glacial conditions, to the shorter duration of the period of glaciation, to long exposure to the decomposing effects of tropical rains and heat, and to the commingling of the classes of phenomena. Therefore the final battle in the glacial controversy must be fought in the settlement of the question of tropical glaciation.

Opinions Adverse to Tropical Glaciation.

Of the observers who have studied the geology of tropical regions, the following, among many others, may be cited as having expressed views adverse to the idea of tropical glaciation:—Charles Darwin, F. R. S., etc.,* Prof. Jno. C. Branner,† Dr. Geo. Gardnier,‡ Dr. A. R. Wallace,§ Prof. Jas. Orton,|| Prof. Jas. E. Mills,¶ Prof. O. E. Derby.**

Of these, Prof. Branner may now be accepted as the leader, since his long residence in Brazil, extended studies and publications justly entitle him to this position; and his conclusions have been accepted by Dr. A. R. Wallace, an able student of glacial physics.††

Besides these, there are many able writers and observers who are loth to accept any views or interpretations involving tropical glaciation, because no natural law has been cited to explain how solar energy could have been arrested and tropical glaciation occur.

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*Trans. Geol. Soc., Vol. VI, 2nd Series, p. 427. "Geological Observations," N. Y. 1891, p. 428, supposes the decomposition took place under the sea.

†Trans. Am. Phil. Soc., Vol. XVI, pp. 419 and 420. Nature, Vol. 48, Oct. 19th, 1893, pp. 589 et. seq. The Journal of Geology, Vol. I, No. 8, pp. 753 et. seq.

‡New Phil. Jour., Edin., XXX, 1841, 75-82.

§Nature, Vol. 48, Oct. 19th, 1893.

||Proc. Am. As. Advancement Sci., Vol. XVIII, p. 198.

¶Am. Geologist, III, p. 361.

**Quart. Jour. Geol. Soc., Vol. XIII, 1887, pp. 457-573.

††Nature, Vol. 48, Oct. 19th, 1893.

See also authorities cited by Dr. Branner, Jour. of Geology, Vol. II, No. 8, p. 771.

Positive Evidence of Tropical Glaciation.

On the other hand, Agassiz,* Hartt,† Belt,‡ De la Beche,§ Blanford,|| Schomburgk,¶ Chardin, Crawford,** G. F. Scott-Elliott,†† Dr. Gustav Eisen,‡‡ Edward Bedloe,§§ and Maj. Ludlow,|||| have all observed post-Tertiary phenomena within the tropics, which are attributed to glacial action.

In addition to this Palæozoic glacial phenomena have been observed to have extended into sub-tropical and tropical latitudes to an extent which necessitates their recognition by any one who would attempt to explain glacial conditions.¶¶

The strongest proof of tropical glaciation is, however, given by Prof. Branner. In order to show how accurately he has described the glacial phenomena of Brazil, the two following quotations are introduced:—the first is from "Elements of Geology," 2nd Ed., pp. 546 and 562, by Dr. Jos. Le Conte.

"THE MATERIALS.—DRIFT. Strewed all over the northern part of North America, over hill and dale, over mountain and valley, covering alike nearly all the country rock, Archean, Palæozoic, Mesozoic and Tertiary, to a depth of 30 to 300 feet, and thus largely concealing them from view, is found a peculiar surface soil or deposit; it consists of a heterogeneous mixture of clay, sand, gravels, subangular stones of all sizes, unassorted unstratified, unfossiliferous—"

"MARSHES AND BOGS. Most of the remains of large herbivores have been found in marshes and bogs. . . .Many very perfect skeletons of the great mastodon have been ob-

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*"Journey in Brazil."

†"Physical Geography and Geology of Brazil."

‡"The Naturalist in Nicaragua," p. 265.

§Trans. Geol. Soc. London, Vol. 2, 2nd Series, pp. 182, 186.

||Quart. Jour. Geol. Soc. London, Vol. XXIX, pp. 493-503.

¶Royal Geol. Soc., p 178.

**Am. Geologist, Vol. VIII, Nov. 1891, No. 5, pp. 306-314.

††Proc. Cal. Acad. Sci., Vol. V, p. 754.

‡‡Quart. Jour. Geol. Soc., Nov. 1st, 1895, Vol. LI, No. 204, pp. 675-6.

§§U. S. Special Consular Reports on Streets and Highways, pp. 520-525.

||||Report on Nicaragua Canal, 1896, p. 15.

¶¶Oldham, Geological Magazine, Vol. XXIII, 1886, as previously cited.

tained from the marshes of New York, New Jersey, Indiana, and Missouri — "

The next is from Prof. Branner's description of boulders, gravels, cobbles, sand, and clay, scattered over hill and dale, over mountain and valley, in tropical Brazil:—*

"This formation is spread over the hills and valleys of the Sergipe-Alagoas basin, and over the adjacent country in the form of a thin coating of cobble stones, pebbles, and sand, sometimes loose and sometimes cemented into a pudding stone as much as ten feet in thickness, and, when exposed, stained black by manganese. It caps the summit of the Tertiary plateaux or their outliers, and is frequently strewn along down the sides of hills, and accumulated in the valleys. It is not confined to the geographic limits of the Cretaceous or Tertiary, but is found further inland and far beyond the present limits of these formations. It is everywhere more or less irregular in thickness, and nowhere can it be said to be universal or continuous. The writer has seen this material throughout Sergipe and Alagoas, in Parahyba, and as far inland as the headwaters of the Rio Ipanema in the interior of the province of Pernambuco, where there is no remnant of stratified Tertiary beds."

"Between the lower Rio Sao Francisco and the frontier of the province of Pernambuco, this water worn material is found mingled in bogs with the remains of extinct gigantic mammals."

"One of the marked characteristics of this post-Tertiary formation is that it is much coarser inland, and grows finer as the coast is approached."†

Prof. Branner accounts for these materials by assuming that at the close of the Tertiary a gradual depression took place.‡ Then a gradual upheaval,§ during which the action of waves is accredited with triturating and depositing these materials on hills and valleys, and strewing them down the sides of hills, and in some unexplained way, these cobbles, gravels, and sands get mingled in bogs with the remains of extinct gigantic mammals.

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*See Trans. Am. Phil. Soc., Vol. XVI, N. S., 1889, pp. 421-422. Also, Vol. I, No. 8, Journal of Geol., pp. 767-768.

†"If a continental glacier moved down the Andes to the Atlantic we would naturally look for porphyritic boulders scattered over the valley and decreasing in number and size as we near Para." (Sir H. H. Howarth, The Glacial Nightmare and the Flood. Vol. II, p. 495. London, 1893.) Dr. Branner has therefore supplied the very evidence which Sir H. H. Howarth considers essential.

‡Many geologists cite facts showing a slight elevation at the close of the Tertiary as accounting for the cold causing the Ice age. Glacialists' Magazine, Vol. I, No. 10, 1894. See also the authorities there quoted by the distinguished geologist, Prof. Upham.

§This is a reversal of the order of upheaval and depression shown

Had Prof. Branner been trying to prove the glaciation of the areas described, he could hardly have made the case stronger than he has. It could only be made clearer by tracing the varieties of stone back to their sources; by showing that the deposits were thinner and more modified than similar deposits further from equatorial regions by reason of the shorter duration of glacial conditions, and the greater time and exposure to modifying agencies; by giving the species, food, and habits of the extinct mammals, comparing them with the corresponding animals elsewhere abundant during the cold temperate periods preceding the Ice age, and by showing that their extinction was caused at the same time and by the same agencies which are known to have rendered cotemporaneous life extinct elsewhere.

But suppose we accept Prof. Branner's interpretations of the origin of Brazilian drift as correct, we are nevertheless confronted with glacial phenomena in other tropical countries which do not yield to a like line of argument, to say nothing of the enormous glacial action in the temperate zones, the accounting for which is only different in degree, and to account for which many able geologists reverse the order of upheavals and depressions suggested by Prof. Branner.*

The same laws and conditions which would arrest solar energy and permit the gradual chilling of our globe from ultra torrid temperatures at all latitudes, down successive gradations until the temperate and polar regions were gripped in ice thousands of feet thick, and until the oceans at all latitudes were intensely cold, would not except even tropical land areas.

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to have taken place elsewhere, and appealed to by many geologists as the cause of a similar deposition of drift in temperate latitudes; it will be seen by examining any standard physical atlas that the coast of Brazil adjacent to the mouth of the Amazon is generally conceded to be gradually sinking.

*When so close an observer as Dr. Branner has to resort to a reversion of the order of upheavals and depressions in Brazil to account for phenomena and facts corresponding to those found in an admittedly glaciated region in North America the homely Scotch verdict of "not proven" must be recorded against his conclusions.

When solar energy was arrested so as to permit the areas now covered by the meadows of England, by the olives of France and Italy, by the cedars of Lebanon, by the palms and bananas of Nicaragua to be glaciated, no suspension of these conditions must be looked for in the tropical plains of Brazil.

Review.

The varying degrees of distinctness of glacial evidences are so important in their bearing upon the climatic evolution now in progress upon our planet, that at the risk of repetition they will be reviewed. Cold temperate areas show unmistakable evidence of having but *recently lost their covering* of glacier ice.*

Near the base of glaciers within the torrid zone and upon less elevated lands in warm temperate latitudes, the same distinctness of recent retreat can be observed.

At or near sea level in regions near the polar circles, as in Alaska, Greenland, northern Europe and Asia, Patagonia, south Georgia, etc., this retreat has been so recent that it is within the range of history, and in very elevated tropical lands, in less elevated temperate lands and in polar regions glacier ice yet rests, and is yet retreating.†

Whilst there are fluctuations in the advance and retreat of glaciers, the general result is that the integral of successive retreats is greater than the integral of successive advances. This is a very marked characteristic over areas where the changes have been noted with great accuracy.

The Temperate Age.

At a period just antedating the Ice age fossil life has everywhere recorded the existence of a warm temperate age. The life systems everywhere attest that a temperature corresponding to the warm temperate zones of to-day existed throughout both hemispheres. Even in Brazil the remains of extinct gigantic mammals, corresponding to the fauna found in North

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*So recent has been this retreat that some geologists have been tempted to make mathematical calculations of the date based on the recession of modern waterfalls.

†Prof. Tarr noted the recent retreat of Greenland glaciers, Am. Geologist, Vol. XIX, No. 4, p. 263; instances of recent glacial retreat in tropical and temperate latitudes are elsewhere given.

America, Europe and Asia, have been found in bogs mingled with boulders and gravel.*

This, the Tertiary period, is subdivided into three epochs, the earliest of which is sometimes found to merge into preceding tropical conditions through a "Transition epoch," although generally the passage is "non-conformable." A marked characteristic of the record made by Nature's thermometers—vegetable and animal life—is that the temperature was practically uniform through the whole range of the present widely varying zones of life.†

The life in Siberia recorded the same temperatures as that on the shores of the Mediterranean; life in Alaska was of the same nature as that in Brazil or Patagonia; so that the fact is of record that there were no zones of temperature—particularly was this the case with marine fauna and flora.‡

The Tropical and Torrid Ages.

During the Mesozoic and Paleozoic ages there existed much warmer temperatures than we have just reviewed for the Temperate age. It would be useless to cite, to even the youngest students of geology, the facts which could be massed to prove the universal distribution of the tropical plants of the Carboniferous age§ or of the warm water marine life of the Silurian age.‖

The manuals and text-books of geology are overburdened with instances and illustrations. Underneath the strata of these ages lie the previous strata of the Cambrian and Laurentian, beneath which lie in turn the enormously thick, non-fossiliferous rocks of the pre-Cambrian and Azoic ages—the border land between geology and cosmology. The minerals composing the rocks of these earlier ages like those of later ages, are presumably worked over materials of previous ages, the traces of which are buried beneath the strata of all subsequent time* and a study of which carries us into the pre-geological ages of cosmology.

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*Journal of Geology, Vol. I, No. 8, p. 767, as previously quoted. In citing biological evidence tending to show that Brazil has never been glaciated, Prof. Branner fails to explain how or why these animals became extinct—although he attempts to show in the face of his own observations to the contrary, that there has been an unbroken succession in tropical life in Brazil since the Tertiary (p. 770 of work cited).

This extinction occurred since the Tertiary. It is at least probable in the absence of definite proofs of some other cause, that these animals became extinct about the same time and through the same agencies by which corresponding life became extinct elsewhere.

†See also Dana's Manual of Geology, 1895, p. 939.

‡Manual of Geology, Dana, 4th Ed., p. 872.

§Manual of Geology, Dana, 4th Ed., p. 711.

‖Manual of Geology, Dana, 4th Ed., p. 574.

We are taught alike in the text-books of the common schools and in the profound treatises of geologists and physicists that during these ages, the earth "was a melted fiery ball, surrounded by a thick atmosphere of gases and vapors. In the course of ages this fiery ball cooled off, and the solid crust of rock wrinkled and cracked and was thrown into ridges and valleys."

"Meanwhile the waters condensed and ran into the hollows. The interior is still hot but the crust is now so thick that but little of the interior heat escapes. The present heat of the surface is derived almost entirely from the sun."†

Of this stage of the earth's climatic development, Sir. A. Geikie says: "At an early period in the earth's history, the water now forming the ocean, together with the rivers, lakes and snow-fields of the land, existed as vapor, in which were mingled many other gases and vapors, the whole forming a vast atmosphere surrounding the still intensely hot globe."‡

We therefore accept the view that the first recorded period of the history of a planet is one during which its own interior heat dominates its surface temperatures and expands the greater portion of the water within the sphere of its control into an enveloping spherical shell.

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*It is well to note here that of the total land area less than 3 per cent is covered by lava, or molten materials from which the heat has partially escaped by conductivity. Beneath these lava covered areas lie all strata antedating the Quaternary period. From but a small fraction of the known geological strata has the earth heat finally escaped except by denudation. How far beneath present limits of geological investigation these worked over materials form the crust of the earth is a matter of conjecture—yet elaborate and profound mathematical calculations of the duration of earth heat are based upon the loss of that heat by "the thermal conductivity of rock masses" and the "rate of increased heat toward the earth's center." And largely upon these calculations is based the idea that earth heat by reason of being shut up beneath a non-conducting crust could not have sensibly affected surface temperatures.

†This quotation is introduced from an elementary textbook on Physical Geography. Warren's New Physical Geography, p. 11. Edited by Dr. Wm. H. Brewer of Yale.

‡Text Book of Geology, p. 33. Sir A. Geikie, London, 1882. See also Essays, Prof. T. S. Hunt, p. 40.

(*Note.*) [There are certain phenomena observed on the planet Jupiter which indicate that it is now in a condition somewhat similar to the above conceived condition of the earth, when its cosmic existence merged into its geological life. So far as our knowledge of Jupiter now extends that planet appears to be a mass of unknown size shrouded in a densely clouded atmosphere. The surface of this cloud sphere is marked by a series of bands and spots ranged in zones parallel with the equator. Another notable feature is the "great red spot," situated in south equatorial latitude and extending through nearly one-eleventh of the circumference of the planet. The spots in the bands adjacent to the "red spot" have velocities greater than that of the "red spot," and in a period of about 45 days make 110 revolutions whilst the "red spot" makes 109. In approaching and passing it from the west they are pushed aside and regain their former position further east. Spots in equatorial regions revolve faster than spots in temperate latitudes.

These and other observed phenomena seem to indicate that the velocities of these spots are probably accelerated by solar energy and that the greater portion of the solar energy reaching Jupiter is absorbed in its atmosphere. Jupiter receives less than 4 per cent. of the heat received by an equal unit of area upon the earth. It is doubtful whether this amount of heat could keep up sufficient evaporation to shroud the planet in clouds. The existence of a cloud sphere about the planet therefore, indicates the presence of a considerable amount of internal heat. This great planet appears to be in a condition which the earth has probably passed through in its climatic development—merely a heated mass enshrouded in a densely clouded atmosphere, through which heat passes principally in the latent form of maintaining water in vaporous condition.]

Now, after admitting that, at any time in the past, internal heat has controlled surface temperatures, we should be careful not to rule it out without reason. The fact that it was originally one of the two known sources of heat, and that whilst it existed at all it must have been the dominant factor, is of sufficient importance for us to look for some record of its subsequent practical extinction, and for marked distinctions between the mode and lines of heat distribution before and after its decadence.

The gradually falling temperatures of the pre-glacial series of climate justifies the view that these temperatures were the direct "manifestations of a dying energy." It is highly probable that there were variations in this energy and that successive increments were sometimes set free from the forming crust of sufficient magnitude to sensibly raise the general temperature; and again that there were land masses of sufficient elevation above the general surface to make marked differences in local surface temperatures. There could have been no suspension of the laws which regulate the distribution of heat as regards altitude.

The great lessons which are distinctly recorded by fossil life are (1) that there was a non-zonal distribution of temperatures during and preceding the Ice age, and distinctly different from the zonal distribution now prevailing; (2) that successive ages of cooler and cooler climates followed one another culminating in a general Ice age.

Between the widely separated periods just reviewed—the remote pre-Cambrian and the present—there has existed a series of climates beginning with an age of ultra torrid temperatures and ending with an age during which elevated lands at all latitudes were loaded with ice hundreds and even thousands of feet thick. During each one of this series there was at sea level a uniform distribution of heat from pole to pole; during some of these climatic eras, and notably during the later ones, ice formed at all latitudes upon elevated regions; during the last of the series of climates, glacial conditions reached a maximum and *marine life of arctic habit first appeared.*

Upon the close of this series there was inaugurated an age of zonal distribution of temperatures distinctly controlled by solar energy and embracing in one era the extreme range of temperatures torrid, tropical, temperate and frigid of the pre-glacial series of climates.

During the earliest ages earth heat undoubtedly controlled surface temperatures; during the present it is no longer an appreciable factor; there lies between the two, the period during which the one source of heat lost its controlling influence and the other source established itself in absolute control. This "transition epoch" was too important a one not to have recorded itself in marked terms. This was the transition epoch of the earth's history, the only transition epoch of geological time.

(*To be continued.*)

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Minerals in rock sections: the practical methods of identifying minerals in rock section with the microscope: especially arranged for students in technical and scientific schools. By L. M. LUQUER, pp. iv, 111. New York: D. Van Nostrand Co. 1898.

While we welcome every English work on this subject, whether of British or American source, this volume deserves special commendation. It is almost the first of those that have come to our knowledge, that, while designed for the student beginner, yet gets down to the beginner's level, omitting abstruse and mathematical discussions, but, with good definitions, making clear the means and the methods of microscopical petrography with a systematic order. Probably the most used English work available, hitherto, is Iddings Rosenbusch, which, coming from the German, possesses some of the prolixity, and the vague complicated expressions peculiar to the German language, and is besides unfit for a beginner unless he has ready at hand a willing and obliging instructor. The work of Harker is like the play of Hamlet with Hamlet left out, since it leaves out all reference to the use of convergent light. The book of Hatch presumes a knowledge of the petrographical microscope and its appliances; that of Rutley, which was one of the first to appear in English, is marred by typographical and other errors, and is badly arranged. The work of Dana (E. S.) 1898, has an excellent chapter on the optical characters of crystals, "characters depending upon light," but that is only a chapter in a general treatise on mineralogy, while the late edition of the work of Brush and Penfield specifically omits all reference to optical methods of determination. We do not mention here the great work of Teall (1888) because that treats specifically of rocks as masses and is on another plane of petrological study. Kemp's Handbook of Rocks has nothing on microscopical methods, and the late work of Moses includes, besides the discussion of the optical characters of crystals, a more elaborate discussion of their geometric characters.

Luquer's work is different from all these in that it defines solely microscopic petrography, and does it in good style and order. It also enumerates the usual rock-forming minerals, giving their microscopic characters in rock-sections. It describes the manner of preparing rock-sections, and of treating them by simple chemical and mechanical tests, and adds a concise chapter on the micro-chemical methods of Boricky and Behrens. It also contains a tabulated scheme, or "key," for the determination of minerals, based, in the first instance, on their comparative double refraction.

The book is elementary, and it could be criticised, but its place has not been filled by any of its predecessors. If it were more full in its own descriptions, instead of referring to other text-books, it would be better, because in making use of this book the student is also, in some instances, required to have several others at hand. But these additions would enlarge the volume so as to make it, what it does not claim to be, a full treatise on microscopical petrography.

N. H. W.

The Islands and Coral Reefs of Fiji. By ALEXANDER AGASSIZ. Bulletin of the Museum of Comparative Zoology at Harvard College, vol. xxxiii; 167 pages, with 120 plates. Cambridge, Mass., May, 1899.

This admirable volume, with its copious plate illustrations (charts sections, and photographic views), and 45 figures, mostly of scenery, in the text, gives a very thorough description of this island group, which the author examined in detail in 1897 and 1898, mainly for the purpose of determining the conditions of origin and growth of coral islands and reefs. He writes: "The islands of the whole group have been elevated, and since their elevation have, like the northern part of Queensland, remained nearly stationary, and exposed to a great and prolonged process of denudation and of aerial and submarine erosion, which has reduced them to their present hight. The submarine platforms upon which the barrier reefs have grown are merely the flats left by the denudation and erosion of the central island, while the atolls are similar flats from the surface of which the islands have at first disappeared and the interior parts of which have next been removed by the incessant scouring of the action of the sea, the ceaseless rollers pouring a huge mass of water into the lagoon, which finds its way out of the passages leading into it or over the low outer edges of the lagoon. These atolls and islands, surrounded in part or wholly by encircling and barrier reefs, have not been built (as is claimed by Dana and Darwin) by the subsidence of the islands they inclose. They are not situated in an area of subsidence, but on the contrary in an area of elevation. The theory of Darwin and Dana is therefore not applicable to the Fiji islands. . . . . . My observations in Fiji only emphasize what has been said so often, that there is no general theory of the formation of coral reefs, either of barrier reefs or atolls, applicable to all districts, and that each district must be examined by itself. At least such has been my experience in the Bermudas, the Bahamas, Cuba, Florida, the West Indies, the Sandwich islands, and Australia. The results of this trip show plainly that Darwin's theory is not applicable to the Fiji islands, notwithstanding the borings at Funafuti, and that, in all the cases I have examined, the reefs form but a thin crust upon the underlying base, the shape and composition of which are not in any way due to the growth of corals of the existing period."

W. U.

Eighteenth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1896-97. CHARLES D. WALCOTT, Director. In Five Parts. Washington, 1897-98.

This report of the work of our national survey during the year ending June 30, 1897, is comprised in six large volumes. Part V, Mineral Resources of the United States, 1896, was published and distributed more than a year ago, as its purpose to promote the development of our mineral wealth required prompt publication; and that part was reviewed in the American Geologist for June of last year (vol. xxi, pp. 380-382). The other four volumes were distributed to geologists and public libraries about two months ago; but several of the papers therein, being earlier issued separately, have likewise been already reviewed in this magazine.

Part I contains the report of the director and an appendix on work done in triangulation and spirit leveling. The appropriations for the survey during the year amounted to $568,690, of which about a third was allotted for topographic work; about a quarter for geologic work, with paleontology and chemical and physical research; $50,000 for gauging streams, investigations of artesian water supply, etc.; $20,000 for the collection of statistics of mining production and resources; $60,000 for engraving and printing maps; and $37,000 for publication of reports. Thirty geologic parties were employed, exploration being done to some extent in nearly every state and territory of the Union; and the director gives brief outlines of the work of each party. Topographic mapping has been extended over an aggregate area of 759,525 square miles, or a fourth part of the whole country. During this year 27,446 square miles were surveyed, and from 10,840 miles of leveling 1,820 permanent bench marks were established.

Eight papers are included in Part II, one of which (Recent Earth Movement in the Great Lakes Region, by G. K. Gilbert) was reviewed in the American Geologist for last February. The scope of the other papers is partly indicated by the following notes.

In the first paper, Prof. Davis presents a very thorough report of his work during twenty years on the Triassic red sandstone and associated trap rocks of Connecticut. The field is one of great complexity, in the diversity of occurrence of the igneous rocks, as dikes, intrusive sills nearly parallel with the stratification, and extrusive flows, the last belonging to three successive epochs; in the deformation by warping, faulting, tilting, and uplifting; and in denudation, base-leveling to a peneplain, reelevation, and sculpture to the present form.

Hill and Vaughan describe a large tract of southern Texas, where the wide coastal plain between the Gulf and the Rio Grande is bordered on the north by the Edwards plateau, the southward continuation of the great plains of the interior. The geologic formations include the Comanche and Gulf series, respectively of Lower and Upper Cretaceous age; Eocene beds of sands, clays, and marls, with lignite, which outcrop on the east and south borders of the tract here described; and alluvial deposits of Neocene, Pleistocene, and Recent age. The springs and artesian wells of the Rio Grande plain, and the underground waters of the plateau on its north side, are found to receive their supply from rainfall on more northern and higher parts of the great plains. Fourteen plates illustrate fossils characteristic of the Cretaceous beds, the Comanche series being divided into ten formations, and the Gulf series into six formations. They are mostly limestones and clays, wholly of marine deposition. The Edwards limestone (formerly called the Caprina limestone), from 250 to 640 feet thick, in the central part of the Comanche series, is described as the most conspicuous and extensive formation in this Texas-Mexican region. From its porous and honeycombed beds, and from the lower Travis Peak sands, artesian flows of excellent water are derived, and many wells have been drilled during the past ten years.

Dall presents a very useful correlation table of our Tertiary formations, assigning them to four chief divisions, Pliocene, Miocene, Oligocene, and Eocene. On the Pacific coast, nineteen Tertiary horizons are distinguished; in the lake beds of the Great Basin, eighteen; in the Gulf states, thirty-seven; and in the Atlantic states, twenty-three. With these is added some discussion of the overlying Pleistocene formations, and of the highest members of the Mesozoic system.

Mount Rainier (or Tacoma), the loftiest and grandest of the four great volcanic mountains of Washington, rising to the altitude of 14,526 feet, bears a radiating shroud of snow and ice, which descends in twenty or more glaciers from one mile to five or six miles long, of which Prof. Russell has given a detailed map and most appreciative description. The mountain consists of andesite and basalt, in large part ejected in a fragmental condition as scoriæ, pumice, lapilli, bombs, etc. These materials were thrown out from a summit crater, gradually building up the volcanic cone, and flows of lava were not abundant during the late stages of eruption. Before the mountain was thus formed, the surrounding country, during late Tertiary time, had been nearly baseleveled, and the resulting peneplain had been uplifted and inclined gently westward. All the glaciers of Mount Rainier show evidences of recent recession at their ends and lowering of their surface. After the formation of the cone, its slopes seem not to have been furrowed by rains but immediately to have become covered with snow and icefields, to which, with the outflowing streams at their lower limits, the erosion forms of the mountain slopes are due. It is hoped that a tract reaching several miles from Mount Rainier on all sides will be set apart by Congress as a national park.

Wolff and Brooks have very carefully studied the white limestone of New Jersey, on which Mr. F. L. Nason wrote several papers in the American Geologist for the years 1891 and 1894 (vols. vii, viii, xiii, and xiv). It is found to be of pre-Cambrian age, distinct from the Wallkill or blue limestone, which is Cambrian, the two occurring in contact at some localities.

San Clemente island, the southernmost off the coast of southern California, having a length of nearly twenty-one miles, a maximum width of about four miles, and a maximum altitude of 1,964 feet, is shown by W. S. T. Smith to be a tilted fault block. The rocks are almost entirely lava flows, with intercalated volcanic breccias and ash deposits, together regarded as of Miocene age; and the faulting which formed this crust-block appears to have taken place near the end of Miocene time. During a Pliocene depression, San Clemente stood about 1,500 feet lower than now, and conspicuous wave-cut terraces at that hight and at many lower levels attest the stages of its reelevation.

Professor Shaler describes the drift formations of the Cape Cod peninsula and the neighboring islands on the south and southwest, with discussion of their mode of origin, correlation, and the attendant epeirogenic movements of the region. The theme is one of great interest to glacialists, and the reviewer contributes an article upon it in the foregoing pages, based largely on his early examination of the same areas.

Part III, Economic Geology, has six papers, of which the first two (by Becker on the gold fields of southern Alaska, and by Spurr on the Yukon gold district) have been previously reviewed. Notes of the others are as follows.

The southern coal fields of the Puget Sound basin, described by Willis, lie within twenty-five miles eastward of Seattle and Tacoma. This Puget formation of faulted, tilted, and folded sandstones, containing the coal seams, has an exposed thickness of 5,800 feet, and it is thought that its total thickness may be 9,000 feet or more. Its age is not clearly ascertained by stratigraphic relations, but its fossil leaf impressions indicate, according to Knowlton, that it is largely Eocene, perhaps continuing to the Miocene. The coal deposits range in quality from lignite to anthracite and coke, the lignite having been locally thus transformed by the influence of igneous rocks.

The Judith mountains, occupying an area eighteen miles long and three to eight miles wide, with peaks rising about 2,500 feet above the plains, which there are 3,500 feet above the sea, had, as shown in the paper by Weed and Pirsson, a laccolithic origin near the close of Cretaceous time. Following the laccolithic uplifts, ore-bearing solutions brought gold into the rocks contiguous to the volcanic intrusions, as revealed by subsequent denudation.

Lindgren describes the geology and mining districts of an area of about 13,500 square miles, surrounding Boisé in western Idaho. The primary gold ores, carrying also silver, are all contained in granitic rocks and associated dikes. The granite, of undetermined age, perhaps Archean, occupies the greater eastern part of the district. Its ore deposits are in fissure veins, provisionally referred to Cretaceous or Eocene time. In the Snake river valley and the valleys of the Boisé and Payette rivers and their tributaries is a thick series of Miocene lacustrine and fluvial beds, including the Payette formation, more than 1,000 feet thick, of sands and sandstones, with plant remains shown by Knowlton to be of Upper Miocene age. Interbedded with the Payette deposits were vast flows of basaltic lavas, distinct from and earlier than the Snake River basalts and associated sediments, which belong to the Pliocene period. Both vein and placer mining have been very productive in the Idaho basin, but the latter is thought to have yielded nine-tenths of the total product of about $50,000,000 since the beginning of mining in 1863. The later mining in the region of the Boisé ridge is chiefly in the vein ores.

The Telluride mining district, in southwestern Colorado, occupying a grandly mountainous map sheet or quadrangle of a square quarter of a degree, is reported by Purington to have yielded in 1896 about $3,000,000, two-thirds being gold and the remainder silver and lead. Its total product, showing a steady increase since the first mining in 1875, has been about $25,000,000. The rock formations, excepting a small Algonkian outcrop, range from the Trias to the Eocene, with later dikes, sheets, and laccoliths of diorite. The Eocene system is probably represented by the San Miguel conglomerate and sandstones, from 200 to 1,000 feet thick, and the overlying San Juan formation of tuffs, breccias, and massive flows of andesite, comprising a thickness of 2,000 or 3,000 feet. After the formation of all the rocks, but probably closely succeeding the latest volcanic action, fissuring, with faulting, was attended by ore deposition.

Part IV, Hydrography, contains four papers. Much geographic and geologic description is embodied in these papers, although they chiefly relate to water supply and to economic problems, largely of irrigation in the arid regions of the great plains and the Cordilleran mountain belt.
W. U.

Preliminary notice of the Etcheminian Fauna of New Foundland. By G. F. MATTHEW. [Bull. Nat. Hist. Soc. N. Brunswick, xviii, vol. iv, p. 189, St. John, N. B., June, 1899.]

By a note at the end it would appear that this article is complementary to one published in the Annals of New York Academy of Science, vol. xii, No. 2, pp. 41-56, in which the stratigraphy of the Etcheminian terrane in New Brunswick and Newfoundland was shown, and its relation to the Cambrian exhibited.

The fauna is peculiar and both in New Brunswick and Newfoundland is marked by the prevalence and large size comparatively, of Hyolithidæ and Patellidæ.

The Hyolithidæ are said to show a full development of family characters and although the genus Orthotheca has more species in this fauna than Hyolithes proper, the fauna is by no means primitive, as the Hyolithes belong to the advanced section Magnidorsati of G. Holm.

The Patellidæ are represented by several ancient genera, among which Scenella and a new genus Randomia are the most prominent. The Calyptreidæ are represented by three minute species of Platyceras.

A minute Modiolopsis was the only lamellibranch obtained, and this is scarce.

The only brachiopods obtained were also quite small, and are of the genera Obolella and Kutorgina.

A few valves of a minute crustacean were met with, which the author refers to the genus Aptychopsis.

The most remarkable feature of this fauna is that no remains of trilobites were found in it. This is a very decided departure from an important charcteristic of all the Lower Cambriam faunas, in which trilobites play an important part.

Dr. Matthew summarizes the points of distinction from the Cambrian faunas as follows:

"1. Great preponderance of the tubeworms (*Hyolithidæ, etc.*)
2. Absence or rarity of trilobites.
3. Minuteness of the gasteropods, except Patellidæ.
4. Minuteness of the brachiopods.
5. Minuteness of the crustaceans."

Die Labradorfelse des Westlichen Norwegens. 1. Das Labradorfelsgebiet bei Ekersund und Soggendal. Von CARL FRED KOLDERUP.

This important and exhaustive paper deals with one of the three areas of anorthosyte and associated rocks in western Norway. The district has not undergone regional metamorphism, so that the results are very helpful in the interpretation of similar eruptive areas where the phenomena are obscured by this process. The details are fully worked out. but for them reference must be made to the paper itself. In parts the paper is highly theoretical, but as this review is intended as an abstract, rather than as a criticism, no discussion of them will be undertaken.

The intrusive rocks of this district have an areal extent of 1450 km^2., of which the anorthosytes cover 956, norytes and quartz-norytes 25, monzonytes 78, adamellytes 150, and banatytes 250 km^2.

Noryte is regarded as the central type of the rocks here occurring and the following chart is presented to illustrate relationships:

Bronzite granite.
|
Adamellyte.
|
Banatyte.
|
Monzonyte.
|
Quartz noryte.
|
Gabbro noryte——Noryte——Labradorite noryte——Anorthosyte.
|
Noryte bronzityte.
|
Ilmenite noryte.
|
Ilmenityte.

Special interest attaches to the more acid rocks, which are of types not widely recognized as yet, and which the author apparently demonstrates to be derived from the same magma as the noryte and anorthosyte. The following analyses illustrate the chemical differences resulting from the differentiation:

	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2	46.85	52.21	53.28	57.11	64.35	70.23	73.47
TiO_2	und.	3.12	1.87	1.59	1.63	1.09	0.12
Al_2O_3	19.72	19.24	23.30	18.00	15.46	15.59	15.42
Fe_2O_3	11.54	10.46	7.55	11.58	7.50	3.05	1.02
MgO	7.75	2.36	3.02	1.78	0.50	1.20	0.20
CaO	13.10	7.28	5.01	3.99	3.38	3.05	1.35
Na_2O	1.56	3.48	3.90	3.96	3.28	4.50	5.57
K_2O	0.09	1.09	1.51	2.59	4.54	1.29	3.64

I. Williams; Noryte from Baltimore.
II. Kolderup; Quartz noryte from Soggendal.
III. Kolderup; Quartz noryte from Theingsvaag near Farsund.
IV. Kolderup; Monzonyte from Fuldland near Farsund.
V. Kolderup; Banatyte from Dypvik near Farsund.
VI. Kolderup; Adamellyte from Farsund.
VII. Kolderop; Bronzite granite from Birkrem.

Unfortunately the analyses are not complete, and the iron is all calculated as the ferric oxide. Three of them are given in complete form elsewhere in the paper. The change consists in a progressive increase in the silica and alkali content, with corresponding decrease in lime, iron and magnesia; hence in more and more alkali feldspar and quartz at the expense of the ferro-magnesian silicates and lime feldspars. Quartz noryte occurs in dikes, and as the central part of the Soggendal laccolith; monzonyte as a central type near Haeskestad and as peripheral type of the Farsund banatyte; the Listerland adamellyte grades into banatyte and at Birkrem adamellyte and bronzite granite are associated.

The author suggests the following as limits between the plagioclase and orthoclase-plagioclase rocks on the one hand, and these latter and the orthoclase rocks on the other:

Plagioclase rocks,-Pl_3—Pl_2Or_1.
Orthoclase-plagioclase rocks,-Pl_2Or_1—Pl_1Or_2.
Orthoclase rocks,-Pl_1Or_2—Or_3.

The passage from noryte into anorthosyte is excellently shown in peripheral parts of the anorthosyte intrusion, and noryte is found grading into ilmenityte through so-called ilmenite noryte.

The Principal Anorthosyte Intrusion.* This consists of anorthosyte and anorthosyte-noryte. The feldspar is labradorite; orthorhombic pyroxene is the usual ferro-magnesian silicate, sometimes a little biotite occurs and occasionally augite, especially in the dikes; ilmenite and apatite sparingly. The chemical characteristics are high alumina (ca. 28 per cent.) and lime (ca. 10 per cent.), low iron (ca. 2 per cent.) and magnesia (0.3 per cent.) and a silica content of from 50 to 54 per cent. Soda is to potash as 6:1. The structure is hypidiomorphic-granular except at the adamellyte contact, as later noted. The anorthosyte consists practically wholly of labradorite of reddish color, while the anorthosyte-noryte shows iron ore and dark silicates, and is of violet hue. They were erupted at substantially the same time, as shown by the gradual passage from one to the other, but at one locality a dike of the violet noryte has penetrated the anorthosyte.

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*The author rejects the term anorthosyte, making the perfectly proper poins against it that it would apply equally well to an albite or oligoclase rock. That doet not, in the reviewer's judgment, furnish sufficient ground for the rejection of a well understood and grounded name. It may in future prove convenient to qualify the term by prefixing the name of the predominant feldspar.

The Rekefjord and Soggendal Noryte. This area is bordered by anorthosyte on three sides, the sea on the fourth, and has an extent of 21 km^2. The central type is of quartz-gabbro-noryte becoming gabbro-noryte toward the sides, the monoclinic pyroxene being less prominent than the orthorhombic. The rock contains apatite, ilmenite, hypersthene, augite, biotite and plagioclase, with hornblende, orthoclase and quartz in the central part. The feldspar of the gabbro noryte is labradorite with a little andesine; of the quartz gabbro noryte, andesine, albite and orthorclase in the proportion of 16: 1: 2. The rock can be regarded as a differentiation product from the anorthosyte marking a further step than the anorthosyte noryte, the SiO_2, Al_2O_3, CaO, and Na_2O decreasing and the Fe_2O_3, MgO, K_2O, and P_2O_5 rising. A dike apparently from the noryte penetrates the anorthosyte. It differs only in having ophitic structure. A small area of similar quartz noryte occurs on Hitteren island.

The Monzonyte near Haekestad. This area comprises 78 km^2. The rock differs from the Rekefjord quartz noryte mainly in its higher potash, hence much microperthite, placing the rock in the orthoclase-plagioclase, rather than in the plagioclase series. Monoclinic pyroxene is more prominent than in the previous rocks, but the minerals are the same and the feldspar content is very large, showing the derivation of the rock from a highly feldspathic magma. Toward the periphery the rocks are more basic, becoming olivine monzonyte and gabbro noryte. This is the only occurrence of olivine in the entire eruptive area.

A dike of the monzonyte penetrates the adjacent anorthosyte so that the former is the younger though the age difference is but slight. The dike rock varies from acid monzonyte in the center to noryte at the sides.

The Adamellyte Area around Birkrem. This is regarded as a laccolith with bronzite granite as the central type, grading through adamellyte and quartz noryte to noryte and anorthosyte noryte as peripheral facies. Erosion has not proceeded far enough to uncover the granite except in a few of the deeper valleys.

This intrusion, covering some 40 km^2., is regarded as younger than the anorthosyte since it has compressed and produced parallel structure in that rock along the contact. The interval between the two eruptions is thought to have been so short that the anorthosyte was not fully congealed, so that the compression of the later intrusion produced parallel structure in the former and at the same time the hot anorthosyte caused very slow cooling of the Birkrem laccolith, thus giving opportunity for the great amount of differentiation which it exhibits.

The granite (analysis VII of the table) is an interesting type of soda granite not heretofore described. It consists of 74 per cent. feldspar, 1.61 per cent. hypersthene, 0.51 per cent. ilmenite and 24.05 per cent. quartz, the feldspar being almost wholly microperthite of the composition $Or_1\ (Ab_7An_1)_{2.4}$.

The Lister Adamellyte Area. This covers 110 km^2. The rock is quite homogeneous throughout though reaching the basicity of banatyte in peripheral portions. The lack of differentiation is explained by the supposition that the enclosing rocks were cold at the time of the intrusion, and that erosion has been deeper than at Birkrem. The rock is very similar to the acid rocks at Birkrem, differing mainly in the proportion between lime and magnesia and the alkalies (analyses VI and VII) so that the microperthite has the composition $Or_1\ (Ab_{4.5}\ An_1)_{4.8}$.

The Banatyte Area east of Farsund. These rocks are reddish and coarse grained, consist of hornblende, reddish feldspar and quartz and have heretofore been called hornblende granites. But the rock is too low in silica and too high in lime (analysis V) to be classed with the granites, and must be put in the orthoclase-plagioclase group on account of the large content of the latter mineral. Peripherally it becomes more basic and belongs with monzonyte (see analysis IV).

The Dike Rocks of the District. Dikes are not particularly abundant but are important, and noteworthy on account of their great length. Dikes of anorthosyte, anorthosyte noryte, noryte, gabbro noryte, quartz noryte, monzonyte, augite granite, banatyte, aplyte and diabase occur, mentioned in order of age, the diabases being the youngest. The larger number are of closely the same age as the corresponding intrusive masses. The comparative age of the granite, aplyte and diabase dikes is uncertain.

Sequence of Eruptions in the District. All the rocks are regarded as differentiation products of a single magma, whose composition is calculated from the areal extent of the various types, a somewhat venturesome proceeding, though not without value. The conclusions in regard to relative age are based on the dikes and the phenomena at the junctions of the different intrusions. The anorthosyte was first intruded. The Rekefjord and Hitteren Island quartz noryte masses followed before the anorthosyte was fully congealed, as did the Heaskestad monzonyte, whose relations to the quartz noryte cannot be determined.

The Birkrem laccolith with its adamellyte and granite is younger than the anorthosyte. The author regards it as also younger than the noryte and monzonyte, arguing that, as it departs much more widely in composition from his calculated parent magma, time for such differentiation is necessary. The same reasoning is applied to the Lister adamellyte, which is younger than, but only in contact with, the anorthosyte. The adjoining banatyte is younger than the Lister adamellyte since it sends a dike into it.

An interesting comparison of these and the Christiania eruptives follows, accompanied by numerous analyses. It is interesting to note that in this country the Adirondack and eastern Massachusetts igneous rocks present a very similar contrast which is not likely to be simply fortuitous.

The Ekersund order of eruption is anorthosyte, followed by slightly more basic norytes and monzonytes, then by the acid adamellytes and granites, finally by the somewhat more basic banatytes, with later basic diabases. The Christiania order is basic through intermediate to acid, followed by basic diabases. This difference is explained by arguing for the differentiation of the Christiania magma before eruption took place, while the Ekersund anorthosyte appeared before differentiation of its magma, after which differentiation of the remainder occurred, then further eruption giving first noryte and adamellyte from the basic upper part followed by the acid material from the center. To account for the appearance of the more basic banatyte further differentiation before eruption is suggested.

The age is supposed to be later Silurian or post-Silurian since the Bergen anorthosyte cuts Upper Silurian rocks and they are assumed to be of about the same age. In the district under consideration the only certainty arrived at is that the intrusives cut pre-Cambrian gneisses. H. P. C.

MONTHLY AUTHORS' CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Bain, H. F.

Geology of Carroll county. (Geol. Sur. Iowa, vol. 9, pp. 49-107, pl. 2, map, 1899.)

Bain, H. F.

Report of the Assistant State Geologist [Iowa]. (Iowa. Geol. Sur., vol. 9, pp. 25-27, 1899.)

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*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Beede, J. W.

Descriptions of some new forms Pseudomonotis from the Upper Coal Measures of Kansas. (Kans. Univ. Quart., vol. 8, April, 1899, pp. 79-84.)

Beyer, Samuel W.

Report of Mr. Samuel W. Beyer. (Iowa Geol. Sur., vol. 9, pp. 28-29, 1899.)

Beyer, Samuel W.

Geology of Story county. (Geol. Sur. Iowa, vol. 9, pp. 155-238, 2 pls., maps, 1899.)

Beyer, Samuel W.

Mineral production of Iowa in 1898. (Geol. Sur. Iowa, vol. 9, pp. 35-48, 1899.)

Broadhead, G. C.

Biographical sketch of George Clinton Swallow. (Am. Geol., vol. 24, July, 1899, pp. 1-6, portrait.)

Calvin, Samuel.

Seventh annual report of the State Geologist [Iowa]. (Iowa Geol. Sur., vol. 9, pp. 11-24, Des Moines, 1899.)

Chalmers. R.

Report on the surface geology and auriferous deposits of south-eastern Quebec. (Part J, Ann. Rept., vol. 10, Geol. Sur. Can., pp. 160, map, 1 pl., Ottawa, 1898.)

Chamberlin, T. C.

Lord Kelvin's address on the age of the earth as an abode fitted for life (II). (Science N. S. 10, 11, July 7, 1899.)

Davis, A. P.

Nicaragua and the Isthmian routes. (Nat. Geog. Mag., vol. 10, July, 1899, pp. 247-266, 3 pls.)

Emmons, S. F.

Plutonic Plugs and subtuberant mountains. (Science, N. S., 10, 24, July 7, 1899. Abstract of paper read before the Geol. Soc. Wash., May 10, 1899.)

Hayes, C. Willard.

Physiography of the Nicaragua canal route. (Nat. Geog. Mag., vol. 10, July, 1899, pp. 233-246, map, 4 pls.)

Heilprin, Angelo.

Geology of the Klondike gold fields. (Pop. Sci. Month., vol. LV, pp. 300-317, July, 1899.)

Hershey, O. H.

Origin and age of certain gold "pocket" deposits in northern California. (Am. Geol., vol. 24, pp. 38-43, 1899.)

Hobbs, W. H.

The diamond field of the great lakes. (Jour. Geol., vol. 7, May-June, 1899, pp. 375-389.)

Hollick, Arthur.

Notes on deep wells at Prince's Bay and Huguenot [Staten Island]. (Proc. Nat. Sci. Assoc., Staten Island, vol. 7, 19, June 10, 1899.)

Keyes, C. R.

American homotaxial equivalents of the original Permian. (Jour. Geol., May-June, 1899, vol. 7, pp. 321-341.)

Keyes, C. R.

Cuesta topography of the Crimean peninsula. (Iowa Acad. Sci., vol. 6, pp. 227-228, 1898.)

Keyes, C. R.

Some physical aspects of general geological correlation. (Iowa Acad. Sci., vol. 6, 1898, pp. 131-154.)

Keyes, C. R.

Permian rocks of eastern Russia. (Iowa Acad. Sci., vol. 6, pp. 229-231, 1899.)

Kimball, James P.

The granites of Carbon county, Montana; a division and glacier field of the Snowy range. (Bull. Am. Geog. Soc., vol. 31, pp. 199-215, plates 1-5, 1899.)

Knight, W. C.

The Nebraska Permian. (Jour. Geol., vol. 7, May-June, 1899, pp. 357-375.)

Logan, W. N.

Some additions to the Cretaceous Invertebrates of Kansas. (Kans. Univ. Quart., vol. 8, pp. 87-98, April, 1899.)

Macbride, T. H.

Geology of Humboldt county. (Geol. Sur. Iowa, vol. 9, pp. 111-154, 1899, map.)

Manson, Marsden.

Observations on the denudation of vegetation—a suggested remedy for California. (Sierra Club Bulletin, vol. 2, pp. 295-311, 2 pls., June, 1899.)

Matthew, Geo. F.

Preliminary notes of the Etcheminian Fauna. (Bull. Nat. His. Soc., N. Bruns'k., 18, vol. IV, pp. 189-197, June, 1899, 3 pls.)

Mosnat, H. R.

Artesian wells of the Belle Plaine area. (Geol. Sur. Iowa, vol. 9, pp. 521-562, 2 pls, 1899.)

Mudge, E. H.

Mouth of Grand river. (Am. Jour. Sci., vol. 8, July, 1899, pp. 31-35.)

Norton, W. H.

Geology of Scott county. (Geol. Sur. Iowa, vol. 9, pp. 390-519, 3 pls., maps, 1899.)

Prosser, C. S.

Correlation of the Carboniferous rocks of Nebraska with those of Kansas. (Jour. Geol., vol. 7, May-June, 1899, pp. 342-357.)

Rogers, Austin F.

Cupro-Goslarite, a new variety of zinc sulphate. (Kans. Univ. Quart., vol. 8, p. 105, April, 1899.)

Sears, John H.

Biotite tinguaite dyke rock. (Bull. Essex Inst., vol. 29, 1897, pp. 58-63, plate. [1899.])

Spencer, A. C.

Report on the rocks of the Wichita mountains. (Am. Geol., vol. 24, July, 1899, pp. 47-48.)

Tarr, Ralph S.

Physical geography of New York state. Part 8. The great lakes and Niagara. (Bull. Am. Geog. Soc., vol. 31, pp. 217-235, 1899.)

Taylor, F. B.

The great ice-dams of Lakes Maumee, Whittlesey and Warren. (Am. Geol., vol. 24, July, 1899, pp. 6-38, 2 pls.)

Turner, H. W.

Replacement ore deposits in the Sierra Nevada. (Jour. Geol., May-June, 1899, pp. 389-401.)

Udden, J. A.

Geology of Muscatine county. (Geol. Sur. Iowa, vol. 9, pp. 248-388, 3 pls., maps, 1899.)

Vaughan, T. Wayland.

Geologic notes on the Wichita mountains, Oklahoma and the Arbuckle Hills, Indian Territory. (Am. Geol., vol. 24, pp. 44-55, July, 1899.)

Vaux, Wm. S., Jr.

Some observations on the Illecellewaet and Asulkan glaciers of British Columbia. (Proc. Acad. Nat. Sci., Phil., 1899, p. 121.)

Wagner, George.

On Tetracaulodon (Tetrabelodon) Shepardii Cope. (Kans. Univ. Quart., vol. 8, pp. 99-103, April, 1899.)

Weed, W. H.

Laccoliths and Bysmaliths. (Science, N. S. 10, 24, July 7, 1899. Abstract of a paper read before the Geol. Soc. Wash., May 10, 1899.)

Winchell, A. N. [N. H.]

Sur quelques minéraux secondaires des roches basiques de la rive septentrionale du lac Supérieur [Minnesota]. (Bull. du Mus. d'Hist. Nat., 1899, pp. 106-108.)

Woodworth, J. B.

Some glacial wash plains of southern New England. (Bull. Essex Inst., vol. 29, 1897, pp. 71-119 [1899].)

PERSONAL AND SCIENTIFIC NEWS.

MR. O. H. HERSHEY proposes (Science, July 14, 1899) that the Spanish term *remolino*, a common designation in the Republic of Columbia for the rounded cavities formed by rivers in their rock-beds be substituted for the English word pot-hole.

PROF. C. E. BEECHER has presented to Yale University his collection of invertebrate fossils, containing many type specimens, the whole numbering over one hundred thousand specimens, "in grateful recognition of the honors and favors conferred upon me during my connection with the University."

DR. W. H. HOBBS, University of Wisconsin, has been made full professor of mineralogy in that institution.

DR. HENRY KUMMEL, of the Lewis Institute, Chicago, has been appointed assistant state geologist of New Jersey.

DR. G. B. SHATTUCK has been promoted to the position of associate in physiographic geology at Johns Hopkins University.

DR. C. R. EASTMAN, of the Museum of Comparative Zoölogy, Cambridge, has advanced vol. I, part 2, of the translated and edited Zittel's Paleontology to such a stage that it can be published by September, at the latest. This part, which completes the first section of the work, brings the paging up to about 700, nearly 200 more than the original, and finishes the descriptions through insects. It contains a very large proportion of new, and especially American, descriptions and figures; the Trilobites, for instance, having been entirely re-written by Beecher, and all the latest results of research upon them incorporated in the paper.

ASSISTANT PROFESSOR R. T. JACKSON, of Harvard University, has gone to Munich for the vacation months, to study the paleontological collections there.

DR. E. B. MATTHEWS, of Johns Hopkins University, has recently been made associate professor of petrography and mineralogy.

PROF. C. S. PROSSER, OF UNION COLLEGE, Schenectady. N. Y., has been elected associate professor of historical geology at the Ohio State University, Columbus.

MR. E. S. RIGGS of the FIELD COLUMBIAN MUSEUM is in the field near Medicine Bow, Wyoming, collecting fossil reptiles for that institution. He is assisted by Mr. H. W. Menke.

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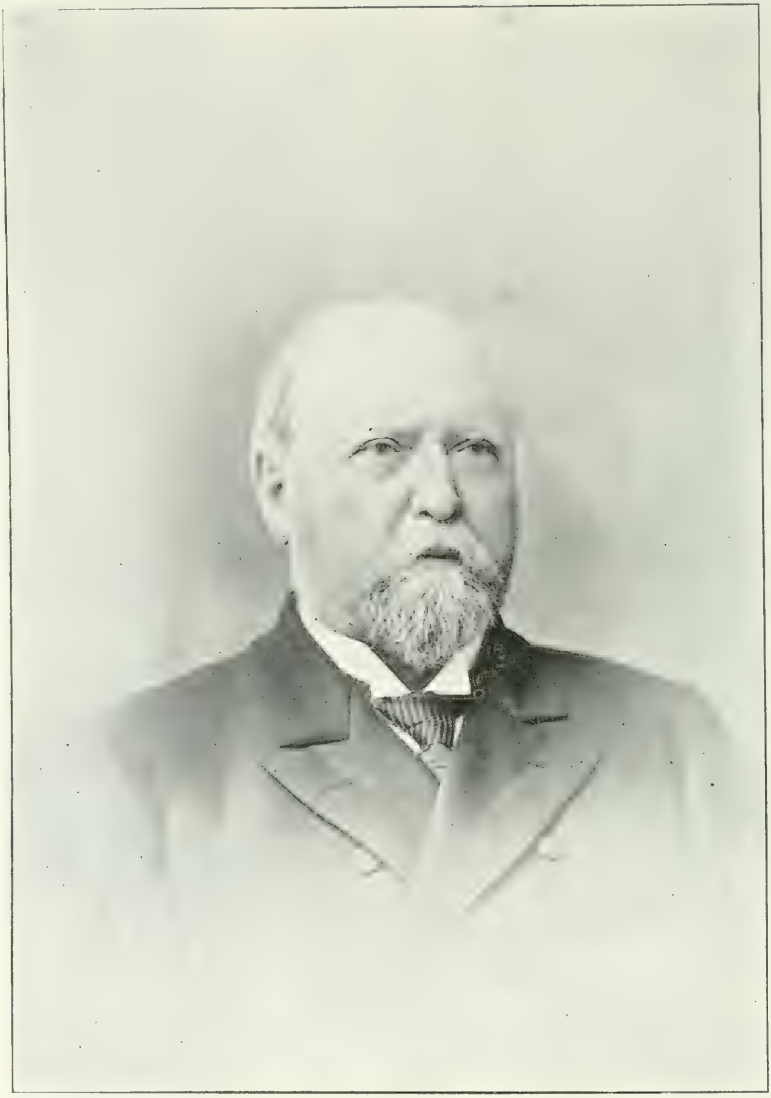

Very respectfully yours
O C Marsh

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OTHNIEL CHARLES MARSH.*

By CHARLES E. BEECHER, New Haven, Conn.

(Portraits.)

Professor Marsh will always be esteemed as one of the most prominent of American investigators in the field of vertebrate paleontology. The nearness of the perspective at the present time, however, renders it difficult properly to individualize and accord the true rank to the many important discoveries he made. He brought forth in such rapid succession so many astonishing things that the unexpected became the rule. The science of vertebrate paleontology could not assimilate new material so fast, and it will be years before the true significance and bearing of much that he has done will be understood. The constant stream of vertebrate riches which, from 1868 to 1899, flowed into the Yale University Museum from the Rocky Mountain region had a similar bewildering effect on Marsh, for it was impossible for him to do more than seize on what appealed to him as the most salient. The work of the hour was to him of prime importance, whether it was for the determination of a new order of mammals or a new cusp on a tooth. Still, he seems to have had a just conception of relative values, for it will be found that he plucked the most luscious plums from the paleontological tree, and left chiefly the smaller or unripe and imperfect fruit untouched.

Another element in his success was seen in the improvement he made in the methods of collecting, preserving, and developing vertebrate fossils, so that even forms long known only from fragmentary remains were represented in his collections by almost complete specimens, presenting nearly the same degree of novelty shown in forms actually new.

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As a collector, Marsh was seen at his best, and the collections he amassed during his forty-five years and more of activity in this direction form a lasting monument to his perseverance and foresight. A person with means and inclination may be supposed to have the necessary qualities for accomplishing his aims, whether they are first editions, autographs, or fossils, but had Marsh possessed no further qualifications than these, the results of his collecting would fall far short of what he really attained. He not only had the means and the inclination, but entered every field of acquisition with the dominating ambition to obtain everything there was in it, and leave not a single scrap behind. Every avenue of approach was made use of, and cost was often a secondary consideration. The nine-tenths, when attained, were only an additional stimulus for securing the remaining one-tenth. Of course, this ideal of completeness was often impossible of accomplishment, and yet it served to bring to the Yale University Museum collections which are unique from their richness and extent.

In making an estimate of his character, it must not be forgotten that he developed wholly without the influence of family and home ties, which in most men profoundly mark their mature life. Self-reliance is probably the strongest trait fostered by the absence of immediate family connections. This, Marsh possessed to an extraordinary degree, and it naturally led to a self-centering of his life and ambitions. Out of it came, also, an absence of the complete exchange of confidence which normally exists between intimate friends. Even where perfect confidence existed, he seldom revealed more about any particular matter than seemed to him necessary or than the circumstances really demanded. As a friend, he was kind, loyal, and generous. As a patron of science, he has seldom been equaled. Honest work in any department appealed to him strongly, and he was ever ready with aid and counsel, even at the expense of a personal sacrifice. His disposition was a most happy one, and he was always keenly appreciative of the humorous and ludicrous and fond of relating amusing experiences and anecdotes. The sunny side of his character was nearly always uppermost, and the consideration of subjects of the greatest gravity was enlivened by constant sparkles of wit from his exhaustless store.

He was normally restive under restraint, and met all opposition with power and fearlessness. Having practically created the modern science of vertebrate paleontology in America, he resented any encroachment upon the particular fields of research in which he was engaged. This attitude frequently developed feelings of hostility in other investigators, and often alienated him from co-workers in his department of science. Nevertheless, he labored faithfully for the truth as revealed in his work, and was ready to change opinions and published statements whenever facts seemed to warrant it.

The world was not slow to recognize his contributions to knowledge, for during his lifetime he received a large number of tangible evidences of distinguished consideration in the way of academic and scientific honors, medals, and membership in learned societies.

In 1886, he received the degree of doctor of laws from Harvard University, and in the same year the honorary degree of doctor of philosophy from the University of Heidelberg. He occupied the chair of paleontology in Yale University from 1866 to the time of his death. He was vertebrate paleontologist to the United States geological survey, and honorary curator of vertebrate paleontology in the United States National Museum. From 1895 to 1899 he was associate editor of "*Science*" and also of "*The American Journal of Science.*"

He was president of the American Association for the Advancement of Science in 1878, and of the National Academy of Sciences from 1883 to 1895. As a presiding officer in the National Academy, he exercised the same amount of care that he bestowed upon his private affairs, and was an active and efficient leader.

In 1877, he was the recipient of the first Bigsby medal awarded by the Geological Society of London, in recognition of his important labors on the vertebrate paleontology of the western territories of the United States. In 1898, the highly valued Cuvier prize was given him by the French Academy, as one of the most able continuators of the science of which Cuvier had laid the foundations.

Prominent among the various societies of which he was a member may be mentioned:

The National Academy of Sciences; Institute of France; Royal Academy of Sciences, Brussels; Royal Bavarian Academy of Sciences, Munich; Royal Academy of Sciences, Bologna; Royal Danish Academy of Sciences, Copenhagen; Royal Irish Academy; Geological Society of London; Geological Society of Germany; American Philosophical Society; Academy of Natural Sciences, Philadelphia; Zoological Society of London; Société Impériale des Naturalistes, Moscow; Geological Society of America, etc., etc.

The subject of the present sketch was born near Lockport, New York, October 29, 1831. His parents were Caleb and Mary Peabody Marsh, formerly of Danvers (now Peabody), Massachusetts. His early education was obtained in the schools of Lockport and at the Wilson Collegiate Institute, Wilson, New York. A residence in a region rich in minerals and fossils is apt to attract the attention of a youth possessing healthy intelligence, and young Marsh soon shared his vacation time between the normal pursuits of shooting and fishing and the more unusual vocation of collecting minerals and fossils. By the time he was nineteen years old, he had thus acquired the taste for scientific subjects which was destined to grow and dominate the remainder of his life.

In 1851, he entered Phillips Academy at Andover, Massachusetts, and continued his studies there until graduation in 1856. He immediately entered the freshmen class in Yale College, pursuing the regular classical course, and receiving the degree of B. A. in 1860. Graduate courses in the natural sciences were continued in the Sheffield Scientific School during the two years following (1861-62). The long summer vacations from 1851 to 1862 were occupied in collecting minerals and fossils from New York, New England, and Nova Scotia. To the latter region he made five trips during this interval, and obtained much valuable experience and scientific material. On his second visit (1855) he found some fossil vertebræ in the Coal Measures at South Joggins, representing a new and important vertebrate animal (*Eosaurus*). This discovery finally directed his studies into the channel which became his life-work. At this time, however, his interests were about equally divided between invertebrate paleontology and mineralogy, and it is worthy of note that his first scientific paper bore the title of "The Gold of Nova Scotia."

The description of *Eosaurus* did not appear until 1862, seven years after its discovery. Even then it cannot be said that he had developed a strong liking for vertebrate paleontology. This closes the account of his student life in American schools.

The next three years were passed in study abroad, in the universities of Berlin, Heidelberg, and Breslau. He attended lectures and took special courses with H. Rose, G. Rose, Ehrenberg, Peters, Rœmer, Grube, and Gœppert. The vacations were occupied, as before, by geological excursions. He visited the most important localities in Europe, and obtained extensive collections. His official connection with Yale College began by his appointment, in 1866, to the chair of professor of paleontology. This title he held in high esteem, as it was the first established either in this country or elsewhere.

After attending the meeting of the American Association for the Advancement of Science at Chicago, in 1868, Marsh went as far west as Nebraska and Wyoming, along the route of the Union Pacific railroad, then just opened. This trip gave him a foretaste of the inexhaustible fossil riches of the Rocky Mountain regions, and thenceforth his energies were mainly devoted to their exploration. Scientific expeditions to the western country were undertakings of considerable magnitude in those early days. There was but one railroad in the United States across a region measuring fifteen hundred miles square. White settlements were sparse and remote. Most of the country was unmapped, and with the exception of a few transcontinental trails, almost the whole western half of the continent, save the regions bordering the Pacific, was a boundless expanse of unknown arid plains, mountains and valleys. Added to these conditions were the indigenous tribes of war-loving Indians, hostile to the whites. Under such circumstances, travel was slow, difficult, and dangerous. It was necessary to have an escort of soldiers and guides, experienced in western life and Indian warfare.

The first Yale Scientific Expedition was organized and engineered by Marsh in 1870. The party consisted of thirteen persons besides the officers and men of the military detachments who escorted them from various military posts along the route. They explored the Pliocene deposits of Nebraska and the Miocene of northern Colorado, then crossing into Wyoming they made collections in the Eocene (Bridger Basin), and passing south discovered a new Eocene basin in Utah (Uinta Basin). At each of these places many important finds were made. The party next visited California, where minor collections were obtained from the Pliocene. Returning, they spent some time exploring the Cretaceous beds of western Kansas, so rich in the remains of aquatic reptiles, and now famous for having furnished the first toothed birds and American toothless flying reptiles.

The second, third, and fourth Yale Scientific Expeditions (1871, 1872, 1873) were modeled after the first. New regions in the West were visited, and extensive series of remains of extinct animals were obtained. Coincident with these discoveries, Marsh published frequent scientific papers describing and illustrating the more important forms, and paleontological literature was enriched by the addition of more startling and wonderful types of animal life than had been hitherto known from the rest of the world.

Owing to Indian outbreaks and a general uneasiness in the West, no regular expedition was organized in 1875. Late in the fall, however, Marsh went to the bad lands of Nebraska and Dakota accompanied by an escort from Fort Laramie to the Red Cloud Agency. The consent of the Indians was deemed necessary to search for fossil bones in their country. A treaty was obtained with difficulty and then assistance was withheld. Nevertheless, with great hardship owing to extreme cold, the party succeeded in reaching the desired region, and made important discoveries, among which numerous remains of the gigantic Brontotheridæ are the most noteworthy.

It was at this time that he became aware of the frauds practiced upon the Indians by the agents of the Government, and the way the Government was in turn defrauded through their misrepresentations. He promised Red Cloud to bring the matter before the President for redress. This was done with signal success, resulting in the complete routing of the Indian Ring, and the downfall of the Secretary of the Interior as well as in his political death.

The rapid settlement and development of the West rendered it no longer necessary to fit out expensive expeditions, especially as many of the localities were easily accessible by railroad. Therefore, after 1876, local collectors and small parties were employed in continuing the work of collecting fossils so successfully begun by the Yale Scientific Expeditions. Nearly every season, however, Marsh visited the localities where work was being carried on, and some time each year was spent in reconnaissance for new fields of labor.

The national Government had not altogether neglected its opportunities for scientific research in the West during this period, though the results in the way of substantial collections were far inferior to those Marsh had obtained. For some time previous to 1878, there were four separate surveys, two under the Engineer Department of the army and two others, extensions of private expeditions, under the Department of the Interior. In the reorganization ordered by Congress in 1878, Marsh, as acting president of the National Academy of Sciences, was the chief instrument in effecting a consolidation and in defining the relations of the present United States geological survey with the general Government and with the United States National Museum. The wisdom of this change was at once apparent, and the survey is now often considered one of the most economical, best managed, and productive departments of the Government.

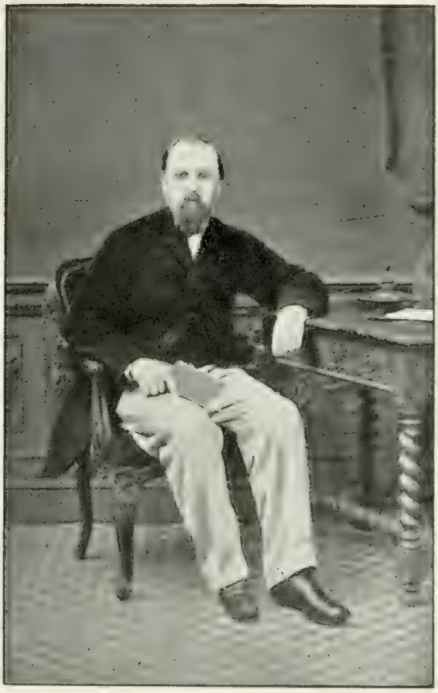
After repeated solicitation and with promises of material aid in the way of publication and collections, Marsh, in 1882, accepted the appointment of vertebrate paleontologist to the United States geological survey. This position he held to the time of his death, although the field work for the survey was terminated in 1892. His connection with the Survey gave him increased facilities for publication and for prosecuting explorations in the West. He successively projected the publication of a number of large monographs on various groups of vertebrate fossils. It is a great misfortune that but two of these were ever finished by the author. The monograph of the Odontornithes appeared in 1880, and that of the Dinocerata in

1885. The others were left in various stages of incompleteness at the time of his death. The proposed volumes treated of the Sauropoda, the Brontotheridæ, the Stegosauria, Theropoda, Ornithopoda, Mesozoic mammals, and the Ceratopsia. Most of the investigations had been completed, a large part of the plates and figures engraved, and preliminary descriptions published, but the philosophical and phylogenetic problems are largely untouched. The loss to science is greatest in the volumes relating to reptiles, especially the Dinosauria, for in this subject Marsh stood as the sole possessor of an acute and comprehensive knowledge of one of the most wonderful and difficult groups of vertebrates known. He planned his life-work on the basis that immortality is here and not in the hereafter. It seemed difficult for him to realize the limitations of human existence and worldly accomplishment.

In the midst of his scientific work and while making plans for the growth of the Museum, he was suddenly overtaken by the malady which resulted in his death. He died of pneumonia, on March 18th, 1899, in his sixty-eighth year, after an illness of about a week. His work as an investigator in natural science, his wonderful scientific collections, and his munificence to Yale, are his legacies to the higher education of mankind.

Although Marsh was an ardent collector in archeology, he published very little on this subject, and his paper (1866) on an Ancient Sepulchral Mound near Newark, Ohio, is practically the only one. His three mineralogical papers, published between 1861 and 1867, show the results of considerable labor and careful investigation. They treat of the gold of Nova Scotia, a zeolite mineral from the same region, and a catalogue of the mineral localities of the maritime provinces of Canada.

In the field of invertebrate paleontology, he likewise was an indefatigable accumulator of material, though after 1869 he published nothing in this department. Two papers presented some annelids considered as new, from the Jurassic of Germany. Another showed the origin of the double lobe-lines in *Ceratites*. His papers on American invertebrates comprised a description of a new genus of fossil sponge (*Brachiospongia*), a new form of crustacean trail from the Potsdam sandstone, and a note on color markings in *Endoceras*. He also showed



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O. C. Marsh. 1867.

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that *Palæotrochis* and *Lignilites* were not of organic origin, though the contrary had been previously supposed.

In the domain of geology, his chief interests lay in the formations from which he secured important series of fossil vertebrates. Probably his greatest geological discovery was the Uinta basin, an Eocene deposit of the eastern Uinta mountains. It was first visited in 1870. Having studied most of the Tertiary lake basins in the Rocky Mountain Region, he gave, in 1875, a synopsis of their geological features. As a natural result of studying geology in Germany, he was much impressed with the methods of marking the separate horizons by means of some characteristic fossil. He believed the vertebrates were the most sensitive time-markers, and therefore endeavored to determine and limit geological horizons wholly by fossil vertebrate remains. The inherent fault of this system is that the vertebrates are not always the most highly differentiated and specialized types in any given fauna, and it is these qualities alone than can be safely employed in organic chronometry. This method is usually of great value in fresh-water deposits rich in vertebrate remains, but it can be seldom used to advantage in marine sediments or in formations containing a scanty vertebrate fauna. Thus, while the name Equus Beds is very appropriate for a horizon in the Pliocene, on account of the abundance of remains of fossil horses, the same cannot be said of the term Eosaurus Beds as an equivalent of the entire series of the Coal Measures, especially as but two vertebræ of this animal have ever been discovered. Geological facts will be found scattered through many of his publications dealing principally with fossil vertebrates. One of the latest problems to interest him was the age of the series of variegated clays extending from Martha's Vineyard south along the Atlantic coast into Maryland. His investigations led him to refer them to the Jurassic, a formation which had been considered as absent in eastern North America.

There yet remains for consideration the real work of his life,—his publications on the fossil vertebrates, and it is at once evident, from a glance at his bibliography, that his chief researches were upon the reptiles, birds, and mammals. There are three papers on fossil fishes, containing notices of several new forms, but no real research in this class was ever undertaken by him. The amphibians also claimed but little attention, and his observations on the metamorphosis of the recent *Siredon* into *Amblysoma*, and two brief notices of amphibian footprints in the Devonian and Carboniferous comprise the whole.

It is with extreme hesitation and a sense of inadequacy that the writer ventures to review, even in the briefest and most superficial manner, the work which undoubtedly constitutes the literary essence of his life-work. Future investigators alone can critically estimate the great mass of facts which Marsh brought out and which he wove into the departments of fossil reptiles, birds, and mammals.

His most comprehensive work, and in many ways the most masterly, is the address delivered before the American Association for the Advancement of Science, at Nashville, in 1877. In this paper, entitled the "Introduction and Succession of Vertebrate Life in America," he traced the introduction of the various types of vertebrate life then known in America, beginning with the lowest fishes and ending with man. The amount of knowledge on the lower classes of vertebrates, including the reptiles, was then too meager to enable him to give more than occasional hints as to their phylogeny. But his handling of the Mammalia showed the clearest insight into the development and affinities of many of the important types, and marked him as a true philosopher.

A glance at the modern text-books of geology and paleontology reveals how much America has done for the fossil vertebrates in the three classes of reptiles, birds, and mammals. It will also show that Marsh contributed more than any other investigator toward the prominence now accorded to the American forms.

His work on the Reptilia is not equally divided among the various orders, for the Dinosauria claimed his attention above all others. To this group he lent his best efforts, and he compassed it so thoroughly as to be its sole master. It seems only necessary in this place to notice the complete restorations he made of some of these remarkable animals. In this list are included *Anchisaurus*, *Brontosaurus*, *Laosaurus*, *Ceratosaurus*, *Camptosaurus*, *Stegosaurus*, *Triceratops*, and *Claosaurus*. It must be remembered that nearly all these animals were of gigantic stature, some of them the largest land animals yet known, and also that each restoration represents a number of separate investigations on the structure of the skull, the limbs, the vertebræ, the pelvis, etc. In most cases, only by this means was it possible to bring together gradually, part by part, until the sum of the knowledge warranted a complete representation of the skeleton. The material of many of the genera he described is still in these various stages of progress, awaiting new additions of portions yet unknown in order to form a finished conception of the entire animal. His extensive report on the dinosaurs of North America, published in 1896, gave a synopsis of what he had accomplished up to that time, but as remarked elsewhere their philosophical treatment he had reserved for his final monographs.

Probably, among the Reptilia, next in importance to his work on the Dinosauria is that on the mosasaurs. In this he first announced the discovery of the dermal armor, the position of the quadrate, the finding of the stapes, the columella, the hyoid, the sclerotic plates, the quadrato-parietal arch, the malar arch, the transverse bone, the pterygoids, the pterotic bone, the sternum, the anterior limbs, the posterior limbs, the length of the neck, and details of the pelvic region. Thus he contributed a knowledge of some of the most essential characters of the skeleton in this group. In other groups of aquatic reptiles, he also brought out new genera and types of structure. Prominent among these may be mentioned *Baptanodon*, a toothless ichthyosaurian. Marsh was the first to describe the remains of fossil serpents in the western Tertiary deposits, and likewise the first to discover the remains of flying reptiles in America. The latter were of unusually large size and remarkable for the absence of teeth.

The acquisition of a unique specimen of pterodactyl from the lithographic slates of Bavaria enabled him to supply the long sought information regarding the wing and caudal membranes. Notices of a number of new species of fossil crocodiles, lizards, and turtles, complete this survey of his work on the Reptilia.

Practically, most of the present knowledge of extinct bird-life in America is contained in Marsh's publications, which include descriptions of numerous species, ranging from the

Jurassic to the Post-Pliocene. Unquestionably, the one discovery which is always foremost in men's minds in a consideration of his work is the determination of an extinct order of birds possessed with teeth. The study of the dinosaurs and toothed birds showed that one by one characters considered as avian were likewise present in reptiles, and that many reptilian characters were present in these primitive birds; so that at the end there did not seem much else besides feathers to distinguish them. Marsh's investigation of fossil birds led to the publication, in 1880, of his first monograph, "Odontornithes: a Monograph on the Extinct Toothed Birds of North America." In this volume, he carefully figured and described all the known types, and presented complete restorations of the two leading genera *Hesperornis* and *Ichthyornis.* He concluded that birds most nearly resemble some of the small dinosaurs from the American Jurassic, and that both classes originated at least as far back as the Trias or late Paleozoic, in some sauropsid type.

A discovery which rivalled that of the toothed birds, although not so wholly his, was the genealogy of the horse. Huxley and Kovalevski traced the equine branch through the Pliocene to the Upper Miocene in Europe, but the true and remote ancestry remained unsolved until the American types were described by Marsh. He showed that a primitive and diminutive polydactyl horse existed in the Lower Eocene, and that from this type, by gradual and progressive change through successive horizons of the Eocene, Miocene, and Pliocene, there had been evolved all the intermediate stages leading to the modern horse.

Next in importance and interest should be noticed the series of papers culminating in the monograph of the Dinocerata, issued in 1886 by the United States geological survey. His work in other groups of mammals is scattered through a large number of separate papers, and contributions were made to every known order. The Tillodontia comprise one of the most remarkable of the types. Among others are the first remains of fossil primates, Cheiroptera, and Marsupialia, known from North America. The Brontotheridæ and Coryphodontia received considerable attention. A monograph had been begun on the former, and restorations of a typical genus of each were published.

One general conclusion of much significance was the outcome of his researches on the mammals. It was that the Tertiary genera possessed very small brains. As a single example, *Dinoceras* may be taken. This animal was but little inferior to the elephant in bulk, but its brain capacity was not more than one-eighth that of existing rhinoceroses.

The first Mesozoic mammal in America was described by Emmons, in 1857, from the Triassic of North Carolina. Marsh, by his extensive discoveries, was enabled to fill up the gaps to the Tertiary with many genera and species from the western Jurassic and Cretaceous. Probably nine-tenths of all the Mesozoic mammals known in the world were described by him, and while these remains are of great interest, yet from their fragmentary condition they are not of the highest scientific value, because little is known beyond the jaws and a few limb bones.

In closing the outline of the discoveries made by this investigator, one cannot help being impressed with their signal brilliancy, their great number, and especially by their unique importance in the field of organic evolution. Were all other evidence lost or wanting, the law of evolution would still have a firm foundation in incontrovertible fact. The study of variation and embryology in recent animals gives hints as to the truth, but paleontology alone can give the facts of descent.

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THE EVOLUTION OF CLIMATES.

By Marsden Manson, San Francisco, Cal.

(Continued from page 120.)

Chapter V.

The Premises and the Solution.

Whenever any line of investigation leads to conflicting or doubtful conclusions—whenever Nature's recorded facts will not fit the theories which have been advanced to account for them, it is best to turn back to first principles.

In the brief review made in Chapter II., of the principal theories urged by various scientists as causes producing the Ice age, it was remarked of the first that it was universally admitted as true, and even taught in elementary works on physical geography, but that it failed to account for all the facts developed by the Ice age. This first theory was a decrease in the original heat of the globe, the truth of which is established by a mass of indisputable geological evidence.

In Chapter IV., an epitome was made of past climatic conditions. These were traced back into the earliest geological periods. At which period it is universally conceded that earth heat was the controlling factor in surface temperatures, we will therefore accept as a premise that at the dawn of geological time two sources of heat influenced the climatic conditions of the earth.

It is necessary to note the peculiar function of each and to mark the date of the sensible extinction of one and the establishment in control of the other.

The mode of heat distribution during the existence of earth heat must have been so different from the distribution after it ceased to be a controlling cause, that nature may be depended upon to have definitely recorded within reasonable and positive limits the epoch when it ceased to act as the dominant agent, and although there may have been "fluctuations in this dying energy," it may be given us to plainly fix the epoch of the transition. We must note also that there were two distinct cooling surfaces, one land and the other water; the latter having a very high specific heat, the former a comparatively low specific heat. A marked difference in the rate and time of cooling, must therefore, be looked for, water cooling much more slowly than earth and rocks, and it was also a prime agent through which the land parted with its heat. In addition to this water appears in three distinct forms each of which possesses remarkable properties in its relation to heat and cold.

It is universally admitted that this original heat has been lost to such an extent that it is no longer the controlling factor in the surface temperature of the earth, and that solar energy is now the controlling source of heat.*

There can be then, no mistaking the first nor the present condition of the earth as regards its exposure to the two known sources of heat—(1) solar and stellar heat,† and (2) resident internal or earth heat. There must have been two marked eras of climatic control—(1) a past era, during which both sources were active; (2) the present era, in which the greater exterior source only remains, the local and lesser source having been largely exhausted.

Or in other words, we have, first, a heated globe having resident in its mass a finite quantity of heat undergoing loss, and exposed to an exterior source of heat and light, which source may be either constant or variable in its energy, but if the latter so slowly that it may be considered sensibly constant during the eras under consideration; second, the same globe deprived of its heat to such an extent that a crust of poor conducting material has formed, the outer surface of which is exposed only to solar heat and space, and whose climates are controlled thereby. The objects in view are to explain (1) the peculiar uniformity of climates prior to the practical exhaustion of the first source, and (2) the occurrence of an age of general glaciation in all latitudes prior to the establishment of the control of the exterior source; (3) the reasons of the differences between heat distribution during geological and present climates.

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*See also Manual of Geology, Dana, 4th Edition, p. 258.

†Stellar heat having the same function as solar heat, and being sensibly a constant of unknown amount but much less than solar heat, need not be separately considered in the further discussion of the question.

To be more explicit, we will state that the prime objects are to demonstrate—

1. That in the passage of the earth from an era during which its climates were controlled by internal heat into an era during which its climates are controlled by solar heat, eras of uniform climates must have been passed through during which isotherms were independent of latitude; and elevation above sea level was the prime cause of climatic variation.

2. That before climates could pass under solar control an age must occur during which elevated continental areas must be glaciated; and that this phenomenon, occurring before solar climatic control, was also independent of latitude.

3. That the direct cause of the Ice age was a combination of the remarkable properties, in relation to heat and cold, possessed by the various forms of water. As water, by reason of its high specific heat, it longer retained the effective remnant of earth heat; as vapor, in the form of fogs and clouds, it largely prevented the loss or receipt of heat by radiation; as ice, it assumed a solid form, storing matter at a low temperature.

We may therefore state the problem in the form of a proposition in which we accept as a fact that the earth was at one time a heated mass, whose resident heat expanded all water, and possibly other volatile matters into a vaporous and gaseous envelope.

*The General Proposition.**

GIVEN: A heated globe, constituted and circumstanced as the earth admittedly was and whose surface temperatures, by reason of internal heat, are above the boiling point of water, to prove that before its surface temperatures can pass under the control of solar heat (1) climatic changes must be independent of latitude, and (2) that continental areas must be glaciated.†

It will be observed that the surface temperatures of a globe thus situated are almost wholly controlled by its internal or earth heat; for between such surface and any external source, a dense cloud of vapor must exist. The fact that direct or radiant heat rays are largely absorbed in passing through dense fogs and clouds is well known;‡ therefore, the surface of a globe thus situated is protected against both serious loss of its own heat and direct exposure to heat from exterior sources.

The peculiar function of solar heat during the existence of controlling quantities of earth heat was to warm the upper regions of the atmosphere and the outer cold surface of the clouds exposed to its power, thus partly replacing the heat lost by radiation into space, and causing the store of earth heat to last longer; its function therefore was to conserve the interior supply.

By the conditions of the problem presented, we thus have a globe having resident in its mass a finite quantity of heat exposed to loss principally by means of the gradual expansion of water into vapor, and the exposure of this vapor to loss of heat by radiation from its upper surface into space. This vapor would then condense, and as rain, snow or hail, descend all, or part of the way, to the earth, receive another increment of heat and ascend as before—a slow process, but exhaustive in time, although retarded by the conservative action of exterior heat sources.

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*The proposition here stated is applicable to any planet. It is probable that Mars has passed through a period corresponding to our Ice age; and that Jupiter has not yet reached this stage of climatic development. [See Zenographical Fragments, London, 1891. Also the author's views in "Circulation of the Atmosphere of Planets." Trans. Technical Society of the Pacific Coast, Vol. XI, No. 4, pp. 127-143.]

†There were circumstances protecting certain limited areas, such as the "Unglaciated Area," in the basin of the Yellowstone river, in North America. Here vast and continuous lava overflows in Wyoming, Idaho, Oregon, and Washington, liberated earth heat; which heat, borne easterly by the general circulation of the atmosphere, may have caused the precipitation upon the "unglaciated area" to be warm rains instead of snow. If so, then to this region the animals and plants of the Tertiary period must have retreated as glacial conditions surrounded them. Thus protected, they could have perpetuated their species. In these regions, vast quantities of their remains are found. See appendix.

‡Maury, Physical Geography of the Sea, 6th Edition, p. 212, et seq.; Croll, Climate and Time, p. 60, et seq.; also, Climate and Cosmology, p. 51; Geikie, The Great Ice Age, pp. 800-801.

Thus the property of water to assume three forms, each of which possesses remarkable qualities with regard to heat and cold, afforded the principal means for exhausting the earth heat. As vapor, it possesses with one exception* the property of storing more heat than any other known substance, and of being, when partly condensed, the most non-transcalent substance known; the high specific heat of water, in the shape of clouds or fogs largely prevents heat from passing until the minute vescicles are expanded into invisible vapor.

As a fluid, it possesses the highest specific heat of any substance composing the crust of the earth; and as snow or ice it possesses the property of storing more cold than any other known substance.

Clouds being more translucent than transcalent, light rays reached the planetary surface more readily than heat rays.

The earth may thus be regarded as having been surrounded by a series of spheroidal isothermal surfaces of mean temperatures. The one next the surface represented a mean temperature of say boiling water at a temperature corresponding to the greater pressure of the heavier atmosphere existing. Above this isothermal shell were others representing mean temperatures of 200°, 90°, 60°, 32°, zero, etc., to —x° Fahr., the extreme cold of interplanetary space.

Between the two spheroidal isotherms of 32° and —x° Fahr., was one which had a mean temperature of 32°—y°, and equally exposed to both sources of heat.

That the spheroidal of 32° Fahr., was within the sphere of influence of earth heat, is proven by the formation of snow or ice at that temperature, both being the resultant of vapor expanded and raised by earth heat to that hight as a minimum. Moreover, vapor would have reached that hight as a minimum were solar and stellar heat suspended for a definite period, and the earth absolutely exposed to loss by radiation from the outer surface of this cloud sphere, with no partial return of heat from exterior sources.

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*Hydrogen.

It therefore follows that the isotherm equally heated by both exterior and interior sources was colder than 32° Fahr., or below that temperature at which snow and ice form. [It is well known that solar energy cannot maintain a temperature as high as 32° Fahr., except in the lower and denser regions of the atmosphere.]

The isothermal surfaces nearest the earth were spheroidal in shape, and by reason of the conditions their surfaces were practically parallel with that of the earth; those most remote from the earth, by reason of solar influences, flattened at the equator and protruded at the poles, so as to be slightly less oblate than the earth. Hence at the equator the direct action of the sun was first felt and established.

As the effective and controlling earth heat was a finite quantity exposed to loss, it was in time exhausted. As this loss proceeded, the spheroidal isothermal shells of mean temperature shrunk in upon the earth, and their contact with its surface marked the lines of corresponding climates prevailing during the dual source of heat. Since the inner isotherms were largely independent of equatorial or polar exposure to solar energy their contacts with the planetary surface established climates practically independent of equatorial or polar position, or in other words of latitude; and not until those depending upon solar energy shrunk to the surface could climates ranged in latitudinal zones be established. As the climates established by the contact of the isotherms inside of the one equally heated by earth and sun were independent of direct solar heat, they varied from the climates established later by solar heat alone; hence the marked difference between climates antedating and succeeding the Ice age. The isotherms preceding this age were dependent almost entirely upon elevation above sea level, fractures, and conductivity of the earth's crust; those succeeding it are dependent upon proximity to the equator, elevation above sea level, and the distribution of heat by ocean currents.

At the expiration of a succeeding period of time, the earth lost sufficient heat to cause the isothermal surface of 90° Fahr., to shrink to the surface except at fractures, and a uniform, moist, and highly torrid climate was established, and types of life developed, culminating in the Carboniferous age.

The crust evidently cooled sufficiently to permit the demarkation of the continental and ocean areas, but the cooling did not necessarily proceed to that point which upheaved the massive mountain ranges, nor greatly depressed the ocean areas. Apparently an era of low, flat continents and shallow hot seas followed.

The life of that period abundantly shows this condition from one polar circle to the other, and the prevailing temperature is recorded in the fossil life of the Palæozoic and Mesozoic eras.

The greater part of the vapors and gases existing previously in the atmosphere were condensed, and existed upon the surface, the vapors as heated oceans, and the gases in various combinations of the mineral and life kingdoms. Now, in the oceans thus formed and further enlarged, there was stored up a vast quantity of the original earth heat, by reason of the high specific heat of water; from which it could not be exhausted until after the cooling of those portions of the surface having a lower specific heat. In this process of exhaustion of this heat, it must have maintained the cloud shield, largely shutting out solar heat until the effective remnant of earth heat was exhausted. Not until the bottoms of the oceans were subjected to a degree of cold approximating that to which the continental areas were exposed could the whole crust be cooled uniformly and attain its present rigidity and stability.

Moreover, in cooling the exposure of one pole to glacial and the other to temperate or sub-tropical conditions, as argued by Dr. Croll, would have subjected our planet to very peculiar "cooling strains," as they are termed by foundrymen. Whereas the slow and uniform cooling, as herein described, is productive of maximum thickness, strength and uniformity of crust.*

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*There is evidently cause why the denser crust materials should have been concentrated in the southern hemisphere. This is in a measure foreign to the present discussion, but two reasons may be suggested, (1) The direction of motion of the solar system in space, and (2) the greater amount of solar energy received by the northern hemisphere.

At the expiration of another succeeding period of time, the spheroidal isotherm having a temperature of say 60° Fahr., similarly shrunk to the surface of the earth, and a corresponding uniformly temperate climate was established.

The further cooling of the crust caused its shrinkage, and a consequent greater upheaval of the lighter areas most exposed to loss of heat, the continents. This further shrinkage caused the strata formed during the previous eras to be upheaved and fractured, and the lines of demarkation between oceans and continents were thus more strongly accentuated.

The life developed in the interim evidences an approach to that of the present temperate zones, and its wide distribution indicates the complete control of the climates of the globe by internal heat. The isothermal lines were entirely at variance with those established by solar heat, therefore the functions of solar heat were principally conservative of those operating on the surface during this period also.

The extreme and uniform distribution of fur or hair-covered animals and of the deciduous and coniferous trees of the Cenozoic era, mark further the control of a source of heat more uniformly distributed than solar heat could possibly be. For reasons previously given, this isotherm also reached continental areas earlier than ocean areas. When the mean temperature of the land was 60° the tepid oceans must have had a higher mean temperature due to the high specific heat of water and to increments of earth heat received from the crust. Whenever the isothermal shell of 32° Fahr. shrunk so as to reach the more elevated portions of the continental areas, a snow line was established independent of the influences now establishing and maintaining such snow line. The resulting glaciation was controlled by the same general laws that now exist, only the distribution of heat being independent of latitude, and mainly dependent upon altitude above sea level, glaciation was as likely to occur in equatorial as in polar latitudes; the only requirement was the existence of land at an elevation above the isothermal shell of 32° Fahr.

The moment a snowflake reached the earth which successive escapes of the waning earth heat were unable to melt, the

Ice age was foreshadowed[*] and the conditions were such as to favor its extension until the effective exhaustion of the store of heat beneath the oceans and resident in them, by reason of the high specific heat of water. It will be noted here that wherever, in obedience to the expansive force of this waning earth heat, a particle of water was vaporized and made the last round of its circulation, it returned to the earth in that form which stored the maximum degree of cold, and which required the action of solar heat to change.

From the moment that snow began to accumulate, the remaining earth heat was available for producing those conditions favorable to glaciation, namely, warm seas, dense fogs and cold continental areas; and the solar energy reaching the upper regions of the atmosphere was available for maintaining those favorable conditions.[†] Glaciations under these conditions would be cumulative until the oceans, partially exhausted of their heat, and approximately reduced to the point of maximum density were no longer able to supply the moisture necessary to shroud the earth from direct solar heat.

At the expiration of still another interval of time, the isothermal surface, having a mean temperature of say 32° Fahr., shrunk in upon the globe, and the oceans were still further exhausted of their store of heat and their bottoms brought in contact with water having a mean temperature of 31° Fahr., a temperature approximating that of the ocean depths at present, and of ice in masses.[‡]

The isotherm 32° Fahr. was a spheroid circumscribing the earth. In shrinking to the earth, its intersections with the surface were controlled by the elevation of the surface above sea level, and by the local escape of earth heat; elevated equatorial or temperature areas were under this interpretation as much exposed to glaciation as polar lands. By reason of the high specific heat of water, this isotherm also reached continental areas prior to reaching ocean areas.

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[*] Probably not until our polar ice caps give place to polar snow caps like those Mars presumably has, which form and melt off with the seasons, will the Ice age have departed from our planet. See Chapter 7.

[†] The prime objection which is urged against all previous theories is their inadequacy. We here have, it seems to the author, a perfectly adequate cause—resident earth heat to supply evaporation and shut out solar energy, which energy can only act the part of a conservator of the glacial conditions until the exhaustion of available earth heat, when its power can be spent in melting ice, and in gradually establishing the present conditions.

[‡] Dr. Jas. Geikie seems almost to reach the same conclusion, for in rejecting the upheaval theory of glaciation he says—"Now it seems easier to believe that the snow line was lowered by several thousand feet than that the continents were elevated to the same extent." The Great Ice Age, 3rd Edition, pp. 792-3.

The crust beneath the ocean, having been protected from loss of heat by the superincumbent water, shrunk approximately to its present shape subsequent to those more exposed portions forming continental areas. The ocean bottoms must also have been fractured, as continental areas had previously been. In this way very considerable increments of earth heat may have been set free after glaciation had commenced. This process which is entirely in consonance with known laws, might result in increasing the depth of glaciation, or even in re-establishing it after partial recedence.

There would also result a complicated series of crust movements as the continents were relieved of pressure by the melting of the ice caps* and the ocean bottoms subjected to increased pressure by the restoration of water to the oceans.†

Thus the same forces which, even before the eras we have been considering, must have built up upon the surface of the globe mineral forms of surpassing beauty, largely to be destroyed and ground down, to give place to vegetable and animal forms of wonderful development—these same forces were called upon to well nigh obliterate every living individual of both kingdoms. The efficiency of their work is attested in every zone of life from the equator to the polar regions.

The continued exhaustion of earth heat in the oceans and beneath them was doubtless accomplished by the same means as before, and this exhaustion resulted in the preservation of those conditions most favorable to glaciation—namely light cloud formations but sufficiently dense to intercept much solar energy. When by the chilling of the oceans to about 31 Fahr., and by the glaciation of continental areas, the air was cleared of obscuring clouds and fogs, the uniform series of climates was at an end.

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*The Great Ice Age, 3rd Edition, pp. 292-3.

†It will again be noted that the isotherms inside of the particular one receiving equal amounts of earth and solar heat were chiefly maintained by earth heat, and therefore largely independent of equatorial or polar exposure to solar heat. Consequently, their intersections were upon different lines from those isotherms exterior to the one above specified; these latter ones were mainly dependent upon solar heat. It will also be observed that much of the solar heat reaching the lower, denser regions of the atmosphere, is trapped or selectively absorbed, and is therefore capable of establishing and maintaining higher temperatures than in the upper atmosphere.

The transition epoch—the date of passage from the control of earth heat to that of solar heat is the Ice age. The transition is still in progress, for solar energy has not yet fully established its control, nor has the Ice age fully departed from the earth.

As in both plant and animal life certain types foreshadowed through long ages the forms which were to follow, so doubtless, too, in earlier ages glaciers formed upon the mountains, and foreshadowed the Ice age which was to follow when earth heat failed.

When the ruptured and denuded crust ceased to yield heat, to be held and conserved by the high specific heat of water, then was the Ice age inaugurated in earnest, to culminate when the last effective remnant of earth heat was wrung from that agent most capable of holding it.

As the oceans approached their point of maximum density then did earth heat cease to dominate surface temperatures, and thenceforth climatic development has been dominated by solar energy. It is reasonably certain that under the vertical rays of equatorial latitudes, solar control was first established in the torrid zone and is still being extended as marked by the vertical retreat of dwarfed glaciers left at great altitudes:—that over temperate and polar regions this power is yet being extended as similarly marked by progressive glacial retreat.

With the dominion of solar heat there dawned upon our planet an era of climatic zones whose lines sensibly follow parallels of latitude; then also began seasons of spring, summer, autumn and winter, with the varying changes due to the earth's annual round.

The climatic changes during the control of earth heat, and within the range of geological research, extended over eras:

1. An era of torrid heat.
2. An era of tropical heat.
3. An era of temperate heat.
4. An era of glacial cold.

Each merged gradually into the others, but each recorded its period of existence in unmistakable terms, all shrouded from the direct action of solar heat, and all evidencing by the life produced, the stifling, smothered character of the climate. During each era glacial conditions could exist locally just as glacial conditions now locally exist in the temperate and tropical zones; during each they could fluctuate as the fading earth heat fluctuated in its outbursts from the forming crust. These fluctuations, towards the last, would tend to cause those puzzling "interglacial periods" to the east of the narrow Atlantic, but less manifest to the east of the broad Pacific.

That solar heat was shut out from the surface of the earth during the Ice age is geologically recorded in the glaciation of the temperate zones over continental areas, where solar energy has removed glacial conditions, and established in their stead a mean annual temperature of 40° Fahr., and in the torrid zone, it has removed glacial conditions and established a mean annual temperature of 76° Fahr., where snow never falls.

Consequently, it appears that in a heated globe, constituted and circumstanced as the earth, exposed to two sources of heat, internal heat and solar heat, before its climates or surface temperatures can pass under the control of solar heat climatic changes must be independent of latitude and the continental areas must be glaciated.

Chapter VI.

The Development of Solar Climates.

In the foregoing chapters, the development of preglacial climates has been briefly traced from a condition of ultra torrid temperature gradually chilling down through a series of climates, each colder than the preceding and each independent of latitude; the last of the series being the Ice age, during which glacial conditions were vastly more extended and lower in temperate and tropical latitudes than they are now. It therefore becomes necessary to explain the development of existing conditions from those prevalent at the culmination of the Ice age. Since this development has been and is a progressive one, it must be interpreted through laws now active, and the interpretation should correctly indicate the state towards which this advance is tending.

At the culmination of the Ice age the snow line was much lower than at present, and elevated lands* at all latitudes were glaciated particularly along lines of maximum precipitation; the seas were intensely cold. It is evident that since the culmination of the Ice age and in the establishment of the present climates there has been a rise in temperatures in the tropical, temperate and sub-frigid zones.

There is also indisputable evidence that this rise in temperature is yet in progress. This accession of heat must therefore be accounted for by the correct application of laws and forces now acting, and to the writer it seems that it is not necessary to go outside of these known laws and forces to render a correct interpretation of the development of the zones of climate now existing.

It will be observed that as the bottoms of the oceans were gradually brought to their point of maximum density and the lands deeply glaciated, the crust was shrunk in upon the interior mass by being uniformly chilled. The atmosphere was then cleared of clouds and heat rays from exterior sources permitted to reach the planetary surface. As previously noted, the moment a ray of solar heat reached the surface and melted a snowflake, that moment was the removal of the Ice age foreshadowed, and the process of its removal outlined.

That the isotherm marked by the glacier is yet slowly retreating upward is recorded not only by tradition and history but geologically and physically, as observed by every scientist who has studied existing glaciers.

This retreat is a positive proof of either a decrease in precipitation on the tributary areas, a rise in temperature, of both of these agencies acting conjointly. There is no evidence to show that a decrease in precipitation is synchronously taking place over the sub-frigid, temperate and tropical regions of both hemispheres, as there is of the retreat of glaciers; and there are positive and active causes in force which must have effected, and are yet effecting an increase in temperature. It is also of geological record that the surface temperature of the oceans has risen since the Ice age, in spite of the cooling effect of the increase of evaporation due to rising temperature.* There is not now, nor has there been at any period since the culmination of the ice, any known source of heat, save solar energy, which is capable of effecting the temperature changes which have come about since the culmination of the Ice age.

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*Except hot or warm lava-covered areas, and the protected or "unglaciated areas" to the eastward of such lava overflows.

We must therefore conclude that this rise in the isotherm marking glacier ice is due primarily, if not entirely, to an accession of solar heat.

It has been demonstrated that at the culmination of the Ice age, much colder conditions existed than at present. It now remains to explain the conditions acting to bring about existing climates. Upon the exhaustion of the effective remnant of earth heat—left in the oceans by reason of the high specific heat of water—the supply of vapor maintaining the cloud envelope was shut off, and solar heat was permitted to reach the planetary surface.

That direct solar rays are converted into obscure or dark heat rays by contact with the planetary surface, and that the atmosphere of our planet is more transcalent to the former than to the latter, has been fully demonstrated by Tyndall,† although slightly modified by subsequent investigations.‡

The researches of Melloni and Langley tend to show that there was a misconception on the part of Tyndall of the terms and mode of action of the heat storing power of media. The latter investigator employs the term radiant energy in place of the simpler expression heat; and expresses the trapping process by the phrase, selective absorption of radiant energy.

As this selective absorption is a cumulative process the results remain the same, whether interpreted along the lines laid down by Tyndall's and Buff's determinations, or along those indicated by Melloni and Langley. Both lead to the same conclusion, namely: That when a body enveloped in media having heat trapping power (or the power of selectively absorbing radiant energy) is exposed to a beam of heat rays from an exterior source, a gradual rise in temperature must follow.

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*At the culmination of the Ice age evaporation reached a minimum by reason of the lower temperature of the oceans; hence precipitation was also at a minimum. Since that age ocean temperatures have gradually risen and hence evaporation has slowly increased; the amount of moisture in the atmosphere, being dependent upon its temperature, has also increased. The aggregate amount of evaporation and the aggregate amount of precipitation must be slowly increasing and have the moderate limit fixed by natural laws.

†Proc. Royal Soc., Vol. XIII, p. 160, Philosophical Transactions, Vol. 152, p. 95; Archives des Sciences, Vol. V, p. 293.

‡Langley's Investigations on the Action of the Atmosphere on Solar Radiation. Mem. National Academy of Sciences, 1885-7.

A gradual rise in temperature was thus inaugurated whenever solar heat rays were permitted to reach the surface, for they are there converted into dark heat rays, which are trapped or selectively absorbed by the atmosphere. This rise must follow whether solar energy be constant or slowly decreasing, the rise being due, not to the actual amount of heat received, but to a positive difference between the rate of receipt and the rate of loss.

The great increase of mean surface temperature in equatorial, temperate, and sub-polar areas can be accounted for by this small but positive difference between the rates of receipt and loss; as has just been shown, this action is yet in progress.

These deductions are radically at variance with the opinion of high authorities on meteorology, as may be seen from the following quotation: "It is evident that our planet, considered as a whole, and on the average of many years, loses all the heat that it receives from the sun, but all the details of this process have not been worked out."*

The author is unable to find any facts to sustain this view—all tend to refute it.

The trapping of heat by vapors and gases of the atmosphere —the gradual retreat of glaciers in both hemispheres—and the vast rise in temperature since the culmination of the Ice age—all corroborate the deductions just reached—namely, that the mean surface temperatures of the globe have been and are yet rising by the trapping of solar heat.

It does not follow that this rise has an indefinite or excessive limit, for as the oceans become warmer they are cooled by giving off more vapor. This vapor, when partly condensed into clouds, intercepts solar heat in the upper atmosphere, and the intense white of the upper surface of clouds reflects more heat into space than the darker planetary surface beneath.

The vast store of cold in the continental ice sheets has been greatly exhausted; there yet remains the vaster store in the ice cold depths of the oceans, the conservative influence of which cannot be estimated; for besides the difficulties of heating water from the surface downwards, there yet remains the cooling effect of surface evaporation. There is thus presented the extreme slowness of the methods by which vast changes are wrought. Here are agencies whose results are so slight as not to be detected by thermometric methods—yet recording their effects in the progressive removal of glacial conditions, and in the establishment and maintenance in their stead of zones of tropical and temperate climates.

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*Dr. Cleveland Abbe, U. S. Meteorological Bureau. Am. Jour. of Science, May, 1892, Vol. XLIII, p. 364.

In this view it becomes possible to trace the steps by which glacial conditions were removed and zones of climate established.

Solar energy first established its control in that zone most exposed to its power—namely, the torrid zone. From this zone, glacial conditions were first removed, and this removal continued north and south upon lines sensibly parallel with present isotherms but modified by precipitation and glacial flow.

In considering the astronomical causes, and the physical results thereby brought about, it has been argued that these causes tended to heat the northern hemisphere more rapidly than the southern. Dr. Croll and other physicists have so fully discussed this question that there remains but little to be added.

The prime reason, however, seems to have been omitted, which is simply this: the northern hemisphere, containing so large a predominance of land area, is more easily warmed than the southern. This unequal heating once inaugurated would establish currents both of air and water tending to perpetuate this action, reinforced as it is by geographical and cosmical agencies.

By the action of the same causes and upon the same principles, the Atlantic ocean has warmed more rapidly than the great Pacific ocean, as shown by the higher temperatures on the easterly coasts of the Atlantic compared with those of the Pacific.

When, by this gradual accession of heat, conditions and temperatures resembling those existing prior to the Ice age, were established, we find these new conditions restricted to latitudinal belts sensibly parallel with the equator, but modified by elevation and ocean currents; whereas the corresponding preglacial climates were independent of latitude, and existed during eras.

By the trapping of solar heat a gradual rise in temperature was inaugurated at that period, when by the exhaustion of the earth heat left in the oceans, the enshrouding clouds were removed. Not until this removal do we find zones of life belting the earth. In these new zones of climate there are being developed higher, nobler types of life, and with the birth of the seasons there was ushered in upon the earth that light which is developing psychozoic life.

Analogies Afforded by the Planet Mars.

The fact that Mars presents phenomena which indicate milder polar climates than exist upon the earth leads the enquiring mind into correct lines in its endeavor to solve the terrestrial problem:

To what conditions are the climatic developments which were inaugurated at the culmination of the Ice age now tending?

The mean distance from Mars to the sun is about one and one-half times the mean distance of the earth; and its volume is about one-seventh that of the earth. Unlike the rest of the planets, its own and other satellites, Mars reflects an orange red light—an important factor in interpreting climatic conditions. Upon equal areas the heat and light received by Mars is less than one-half that received by the earth; it by no means follows that its climates are proportionally colder, for as is well known in the case of the earth, the actual amount of heat a planet receives is not the prime factor in its surface temperatures. There are other factors which bear an important part, and arguments omitting these are liable to be fallacious. It is the omission of such factors which has rendered the climatic conditions presumably prevalent upon Mars difficult of interpretation.

As either pole of Mars emerges from its winter, a comparatively large white area is observed to encircle it. This area generally reaches down to Lat. 84° or 82°, or 6° or 8° from the pole, although sometimes extending to Lat. 60° to 55°, or through an area having a diameter of from 60° to 70°; this white area disappears as the pole is turned towards the sun in the following summer. The disappearance on the edges is rapid, but the true polar areas are persistent for months. They are evidently composed of that constituent of the atmosphere of the planet which has the highest freezing point, for upon their disappearance we observe the surface of the planet.*

These phenomena admit of the simple explanation usually rendered, namely, that these areas are polar snow-caps which form and melt off with the seasons; but the task of explaining how a planet receiving less than half the heat and light which the earth receives could enjoy so mild a winter and so warm a summer at polar latitudes has by some been considered difficult.

The Omitted Factors.

In the life of a planet we have seen that there may be a period between the effective exhaustion of its own available heat and the reign of solar heat, during which period glacial conditions are extensive for a great length of time. This period the earth has manifestly passed through, as continental glaciers once existing have disappeared, and the isolated glaciers are yet retreating upwards and polewards in tropical, temperate, and even polar latitudes.

It has been stated that the actual amount of heat received by a planet was not the sole factor influencing its surface temperatures; other factors are equally and perhaps more important. Their existence and influence are made apparent in the general rise in terrestrial temperatures since the culmination of the period of great glacial extension over now temperate and tropical areas. One of these factors or causes is the power of the atmosphere to trap or selectively absorb solar energy.

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*It has been argued by some who think that because Mars receives less than .43 of the solar heat which the earth receives that its climates must necessarily be much colder than ours; and that these polar seas may be congealed carbon dioxide, (CO_2) which has a freezing point of –109° Fahr. (See Publications of the Astronomical Society of the Pacific, Vol. VI, No. 38, pp. 380, 300, 302. Also Vol. VII, pp. 54-55.)

To the writer this idea is, however, untenable, for before the low degree of 109° below zero Fahr. could have been reached, all vapor of water and other volatile constituents of the atmosphere of Mars, congealing at a higher temperature than –109° Fahr. would have condensed, and would permanently shroud the planet in white. Upon this surface the deposition and melting off of the equally white carbon dioxide could not be observed.

Tyndall and Buff have shown, as previously noted, that solar light and heat-rays are largely converted, by contact with the planetary surface, into dark heat-rays, and are trapped; and that this power to trap dark heat-rays is held individually and collectively by the various constituents of the atmosphere.

Now, when this heat trapping or selective absorption process is inaugurated upon a planet, it is no longer a heat-losing body, but within certain limits, it is converted into a heat-gathering body in space; for its rate of receipt of heat is greater than its rate of loss. The process has a moderate limit fixed by the evaporation of water, which evaporation, when excessive, shuts out solar energy by extensive cloud formation.

The mean surface temperatures of the earth have thus gradually risen from the lower temperatures prevailing during past glacial extension. As the progress of this rise is yet being recorded by the retreat of glaciers in both hemispheres and at all latitudes, and as it was inaugurated at a comparatively remote period in the past, the element Time has entered into the result as a third important factor.

Thus the solar climates of a planet are determined by three prime causes or factors; first, the actual amount of heat and light received; second, the heat trapping power of its atmosphere determining the difference between its rate of receipt and rate of loss of heat; third, the time these two factors or causes have been operating.

In the application of this reasoning to Mars we can fix, in general terms, the existence and positive character of each cause; the logical result of the combination being that Mars may enjoy a milder climate than the earth.

As regards the first, the amount of heat and light Mars receives is readily calculated to be about 0.43 that received by the earth.

The existence and operation of conditions tending to abstract and retain solar energy is made manifest by the deficiency of blue rays and the excess of red and orange rays in the solar light Mars transmits to us, the color of this transmitted light indicating that the Martian atmosphere has the power of abstracting and retaining those rays which are most readily trapped, or selectively absorbed by the atmosphere of the earth. This deficiency in the rays most readily trapped indicates that there is a positive difference between the rates of receipt and loss of solar energy; or in other words that Mars, like the earth, is a heat-trapping body, and that either its surface temperatures are yet gradually rising; or, that its mean surface temperatures are practically constant, and the deficiency of solar energy represented by the absence of the blue rays is used in maintaining these constant conditions, and in work upon the planet's surface.

The third cause—the factor time—is necessarily greater than the corresponding factor in the case of the earth; for Mars, having a mass less than one-ninth that of the earth, must have lost its internal heat at an earlier period, and therefore became a heat-gathering body at an earlier period than the earth.

Thus three of the principal factors influencing climate are positively and probably cumulative in their effects for long periods of time. It is therefore reasonable to infer that similar climatic conditions must in time be established upon any planet having a heat-trapping atmosphere, and that the milder conditions indicated by the annual melting off of the polar caps of the planet Mars are those toward which the progressive rise of temperatures since the culmination of the Ice age indicate for the future of the earth.*

Chapter VIII.

The Cosmic Laws of Climatic Evolution.

The writer has endeavored to show that the glaciation of a planet is the direct and necessary result of known laws, and the culmination of a series of uniform climates controlled by the resident internal heat of the planet; that upon the close of this series solar energy gradually established its control, and that these processes have constituted a system of climatic evolution, controlled by known laws.

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*The observations of Dr. Barnard at the Lick Observatory corroborate these conclusions. Dr. Barnard says of the results of an extended series of observations of the south polar cap, in 1892-4: "That the cap steadily diminishes after the summer solstice, showing that, as on the earth, the temperatures of Mars continues to rise after the summer solstice—the maximum temperature occurring several months after the maximum of solar heat has been received, thus indicating a heat storing atmosphere. This fact is in good agreement with Dr. Manson's interesting paper on the climate of Mars, in Popular Astronomy for April."

Popular Astronomy No. 20, 1895.

The cosmic laws of climatic evolution will be presented in the form of a series of postulates and corollaries. It is believed that these will be generally admitted as true, at all events, anyone can readily satisfy himself regarding them.

(1) Heat rays cannot pass through fogs and clouds, formed of the vapors of a fluid having the physical properties of water, except in a very greatly diminished intensity.*

(2) A hot spheroid rotating in space and holding water and air (or fluids of similar properties) within the sphere of its control, gives off and receives heat subject to its passage through clouds. The spheroid must lose heat principally by the expansion of water into vapor and by radiation from the cool outer surface of its cloud envelope, which envelope is maintained by the evaporation of water by the heat of the spheroid, and conserved by heat reaching it from exterior sources; during its existence it acts as a conservator of the heat of the spheroid.

(3) That in the stages of cooling subsequent to the formation of oceans, land surfaces must, by reason of their low specific heat, cool faster than oceans; and that heat reaching the planetary surface by the circulation of meteoric or included water or by convection, or set free by denudations, faults and fractures, is principally taken up by water in its fluid and vaporous form, and conserved by water in the form of clouds.

(4) The surface temperatures of such a spheroid must be practically independent of exterior sources of heat until the greater portion of the water surrounding it be reduced to its point of maximum density or converted into ice, and that prior to this stage of its climatic evolution, its surface temperatures are practically controlled by interior (or planetary) heat, and are practically independent of latitude; and are therefore independent of the temperature to which the outer surface of the cloud sphere may be exposed. The effect of variations in exterior heat being mainly to increase or decrease the duration of the interior supply, and to expand or contract the sphere

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*Maury. Physical Geography of the Sea, 6th Ed., p. 212, et seq. Croll—Climate and Time, p. 60. Climate and Cosmology, p. 51. Geikie, J.—The Great Ice Age, pp. 800-801.

of cloud condensation. The principal function of exterior heat, prior to the chilling of the oceans, being conservative or to replace in part the heat lost by radiation from the cold outer surface of the cloud sphere.

(5) That until the exhaustion of the available internal heat supply, outside of a crust of low conductive power, the surface temperatures of the spheroid must be nearly uniform from pole to pole, varying only with elevation above sea level, or from local causes, such as the influence of lava outbursts upon the areas to the leeward of such outbursts. And that a series of uniform climates must prevail independent of latitude, and gradually decreasing in temperature as the spheroid loses heat.

(6) That the low specific heat of land areas permits them to cool more rapidly and to reach glacial temperatures before the oceans are reduced approximately to the point of maximum density, and consequently that snow must accumulate upon these areas until the oceans cease to give off sufficient vapor to shield the earth from solar energy. That these accumulations of snow must reach their maxima along belts of maximum precipitation, and must be independent of latitude.

(7) That upon the chilling of the oceans, the supply of vapor maintaining the cloud envelope is cut off, and the atmosphere deprived of the greater portion of its heat intercepting power; and that heat rays from exterior sources then reach the planetary surface in sufficient quantity to dominate its climates. That a new distribution of temperatures is thereby inaugurated dependent principally upon latitude or exposure to exterior sources, and modified by elevation and local causes.

(8) That solar rays by contact with planetary surface are partly converted into dark or obscure rays and are trapped,* or are selectively absorbed.† That a gradual accession of heat must be thereby inaugurated, resulting in the removal of glacial conditions and that such removal of glacial conditions must be on lines determined by the degree of exposure to

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*Tyndall—Proc. Royal Soc., Vol. XIII, p. 160. Phil. Trans., Vol. 152, p. 95. Archives des Sciences, tom. V., p. 293.

†Langley—Investigations on the Action of the Atmosphere on Solar Radiation. Mem. Nat. Academy of Sciences, 1885-7.

Buff—Archives des Sciences, tom. LVII, p. 293.

solar energy, and the susceptibility of the different portions of the globe to be influenced by such exposure. That these new conditions must inaugurate a new distribution of temperatures ranged in zones and subject to solar control.

The necessary corollaries of these postulates are: (a) That a planet having water and air within the sphere of its control, which has not yet exhausted its internal heat, must be densely shrouded in clouds whose outer surface presents a high albedo.

(b) That a planet whose internal heat has been practically exhausted, and which holds water and an atmosphere within the sphere of its control must reflect solar energy deficient in those rays which are most readily trapped, or selectively absorbed by its atmosphere, and it must have a low albedo, and that the color of its reflected rays must be controlled by those least readily utilized and trapped.

(c) That glacial conditions may exist locally during any period of a planet's climatic evolution provided there be regions sufficiently elevated; but that an Ice age occurs as its oceans are finally exhausted of their available remnant of planetary heat; that this age marks the period during which surface temperatures pass from interior to exterior control, or is the transition period of its climatic evolution, and is unique

(d) There are two great eras in the climatic evolution of a planet; 1st, the era during which its internal heat controls its surface temperatures, and solar heat acts principally as a conservator of interior heat; 2nd, the era of solar control of climates. The former being an era of gradually decreasing temperatures of uniform distribution at sea level; and the latter an era of gradually rising temperatures of a zonal distribution. The two eras, so far as land areas are concerned, must be separated by an Ice age. The differences in the specific heat of land, and that of water, permits the land areas to cool first. The precipitation of snow upon them must therefore have been cumulative, until the oceans were reduced to about the point of maximum density.

It is reasonably certain that glacial conditions were first removed from equatorial regions, and that maximum glaciation of land areas in temperate latitudes may have occurred subsequent to the inauguration of solar control over equatorial latitudes, and that polar glaciations may have reached their maximum at a period subsequent to the commencement of the disappearance of glaciations in temperate latitudes.

(e) The accession of solar heat by the trapping process being the result of a positive difference between the rate of receipt and the rate of loss, and not being a function of the orbital distance, a rise in temperature may as certainly follow in one position as another.

(f) That glacial conditions although imposed upon lines independent of solar exposure, must have reached their maximum upon areas subject to maximum precipitation, and as the movement of the atmosphere in temperate latitudes is towards the east, the west coasts of continents are more exposed to the moist winds and hence were more deeply glaciated than the east coasts. The narrow North American continent was thus more exposed to glaciation from the wide Pacific than was the broad Euroasian continent from the narrow Atlantic.

(g) That the northern hemisphere of low specific heat has progressed further in climatic development than has the southern hemisphere of high specific heat. Similarly, the Atlantic has been warmed to a greater extent than the Pacific.*

[*To be continued.*]

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On the Phenocrysts of Intrusive Igneous Rocks. By L. V. PIRSSON. Am. J. Sci., 157, 271-280.

The objections to the hypothesis of an intratelluric origin of the phenocrysts are discussed, and evidence pointing to an origin by crystallization "in place" is presented. The supposed manner in which the development takes place is as follows: As the temperature of an intruded aqueous magma falls, centers of crystallization are set up, the intervals of crystallization of the component minerals becoming progressively shorter as the magma becomes viscous from the escape of the water-vapor. Thus, while the earlier, or ferro-magnesian, components may reach considerable size, the crystals of the later components are comparatively small. In the case of recurrent phenocrysts it is supposed that the most abundant components tend to set up centers of crystallization before their normal periods, the rest of the process continuing as before. M. L. F.

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*It will probably be noted that no mention is made of light rays; these can be filtered by clouds and pass through in greatly diminished intensity. It is not considered necessary to discuss their influence at this point, as their effect is slight at temperature approximating the freezing point. The gradual development of visual organs and the development of all other senses prior to that of sight are lines of investigation which the author has not been permitted to make.

On the Occurrence, Origin, and Chemical Composition of Chromite. By J. H. PRATT. Am. J. Sci., 157, 281-286.

The usual mode of occurrence of the chromite of North Carolina is in the form of rounded masses of varying proportions in the peridotite near its contact with the inclosing gneiss. Its basic character is an indication of its insolubility in the peridotite magma; hence it would have been among the first of the minerals to solidify. Its relation to the inclosing rock confirms this view. With two exceptions, all analyses known show the presence of magnesium and aluminum, and the author concludes that chromite is really a combination of the three isomorphous molecules, $FeO.Cr_2O_3$, $MgO.Cr_2O_3$, and $MgO.Al_2O_3$. The $MgO.Al_2O_3$ is represented by the mineral spinel, and the discovery of $MgO.Cr_2O_3$ as a definite mineral may be expected.

M. L. F.

Some Rock-forming Biotites and Amphiboles. By H. W. TURNER. Analyses by W. F. HILLEBRAND, H. N. STOKES, and WILLIAM VALENTINE. Am. J. Sci., 157, 294-298.

The paper includes descriptions and very complete analyses of biotite from granite, quartz-monzonite, and gneiss from the Sierra Nevada region, and of the amphibole of gabbro and quartz-monzonite from the same locality. Complete analyses of most of the rocks are also given. The work was executed in the laboratory of the U. S. Geol. Survey, the object being to furnish a basis for calculating the molecular composition of the rocks in question. M. L. F.

On the Occurrence of Paleotrochis in Volcanic Rocks in Mexico. By HENRY S. WILLIAMS. Am. J. Sci., 157, 335-336.

More or less regularly striated biconical forms resembling the supposed coral Paleotrochis of Emmons were found by Alfred Dugès in the volcanic rocks of an old eroded cone northeast of Guanajuato in the Santa Rosa mountains. The explanation is suggested that in the upward passage of superheated siliceous waters through the rock a point might be reached where a sudden loosening of the texture would permit a rapid upward radiation of the heat, while below the point the temperature would remain nearly constant for long periods. Deposition would take place wherever a cavity existed, but the supply of silica would be furnished only as it was abstracted by solidification. It is considered that the cavity would be increased in size by the crystallization, and that "the accretion-surface would increase with the lengthening of the cone by the separation of the apices of the cones, consolidation taking place at the point of meeting of the solidified silica with the water, and the water reaching that point slowly." M. L. F.

Origin of Paleotrochis. By J. S. DILLER. Am. J. Sci., 157, 337-342.

A summary of the reviews of previous writers, and descriptions of both the macroscopic and microscopic characters of specimens from Mexico (see preceding review), and from the San Christian Gold Mine of North Carolina are given in some detail. In both cases the Paleotrochis occurred in igneous rock, the analysis of the North Carolina type, which is given in full, indicating a rhyolite. The more perfect Paleotrochis are composed of granular quartz and were deposited within the more or less elongated spherulites with which the rock abounds, but whether this deposition followed soon after that of the spherulites in the course of consolidation, or took place in hollow spherulites (lithophysae), or were the result of subsequent alteration, is not clear. The biconical forms suggest that they may have originated as two spherulitic sectors, of which the apices were the centers from which the growth started. M. L. F.

On the Association of Argillaceous Rocks with Quartz Veins in the Region of Diamantina, Brazil. By ORVILLE A. DERBY, Am. J. Sci., 157, 343-356.

The paper discusses in detail the characters and probable origin of certain more or less strongly decomposed rocks of the Diamantina district. An exhaustive analysis of a cyanitic schist from the region in question, made by W. F. Hillebrand, is included, M. L. F.

Goldschmidtite, a New Mineral. By WILLIAM H. HOBBS. Am. J. Sci., 157, 357-364.

The new mineral, to which the name of goldschmidtite has been given by the author, is a brittle, silver-white substance, having a hardness of about 2 and a specific gravity of 8.6. It is found in the form of minute columnar monoclinic crystals attached to the chalcedonic coatings of the fragments of a brecciated igneous rock of the acid type occurring at the Gold Dollar Mine, Arequa Gulch, Cripple Creek. The analysis shows the presence of 31.41 per cent of gold, 8.90 per cent. silver, and 59.64 per cent. tellurium, corresponding to the formula Au_2AgTe_6, and giving it a position intermediate between calaverite and sylvanite. Twenty-two crystal forms were recognized, ten of which are also recognized in sylvanite, to which the new mineral is most closely allied. M. L. F.

On a Hydromica from New Jersey. By F. W. CLARKE and N. H. DARTON. Am. J. Sci., 157, 365-366.

This golden-bronze mineral, which differs widely from any hitherto-described mica, is found mainly as thin coatings in veins of calcite adjacent to the diabase wall rock at Rocky Hill, N. J. The analysis indicates an orthosilicate of the formula

$$(KH)_{68}(MgFe)_{24}(AlFe)_{31}(SiO)_{67}.28H_2O,$$

pointing to a mixture of muscovitic $(R'''(SiO_4)_3R'_3)$ and phlogopitic $(R'''(SiO_4)_3R''_3H_3.3H_2O)$ molecules in the ratio of 9 to 5. M. L. F.

Iowa Geological Survey, Volume IX: Annual Report, 1898, with Accompanying Papers. SAMUEL CALVIN, State Geologist; H. F. BAIN, Assistant State Geologist. Pages 572; with 8 geological maps of counties, 13 plates, and 56 figures in the text. Des Moines, 1899.

One third of Iowa has been mapped in detail, including thirty-three counties, seven of which were surveyed during the year 1898. Besides the administrative report of Prof. Calvin, the present volume contains reports on five counties, namely, Carroll, by H. F. Bain; Humboldt, by Prof. T. H. Macbride; Story, by Dr. S. W. Beyer; Muscatine, by Prof. J. A. Udden; and Scott, by Prof. W. H. Norton. For Carroll and Humboldt counties, a single map of each is presented, showing the drift formations and the very restricted exposures of the underlying rocks; but each of the other three counties has two maps, one noting the surface deposits, and the other the older rock formations. There is also a paper on Mineral Production of Iowa in 1898, by Dr. Beyer; and a Report of the Artesian Wells of the Belle Plaine Area, by H. R. Mosnat.

The value of the chief mineral products is stated as follows: Coal, $5,123,187; clay, $2,057,022; stone, $563,586; and lead and zinc, $43,784; in total, $7,787,579. To this ought probably to be added about $75,000 as the value of the gypsum product, for which exact figures were not obtained.

Each of the county reports well describes the topography and the geology, stratigraphic, glacial, and economic. It is evident that excellent progress is being made in thorough investigation of the geologic history and resources of Iowa. With the careful exploration and study already given to so many counties, distributed in all parts of the state, the work of the survey may be regarded, probably, as half done, since its general outlines and principles have now been mainly determined.

The classification, areal and time relations, and conditions of origin of the complex series of drift formations, already quite satisfactorily ascertained, are perhaps together the most important contribution of the Iowa survey to the advance of American geology; in which, however, this state owes much to earlier and to contemporaneous workers in the adjoining states. While we may still, according to the opinion of the reviewer, consider the Glacial period as continuous for the continent, it was divided in Iowa, near the boundary of the continental ice-sheet, by intervals of great recession and readvance of the ice-fields.

In this upper part of the Mississippi river basin the Ice age was more complicated, apparently, than in either the Atlantic or the Pacific coastal region, or in the interior of Canada. Five distinct and successive deposits of till are recognized in the parts of Iowa here reported, alternating with interglacial beds, zones of weathering, and soil formation. The series represents, as may be thought, stages of the oncoming, culmination, and wane of a single continental Ice age; but if we regard this state alone, it records at least two epochs of snow and ice accumulation, divided by a long epoch of deglaciation.

The pre-Kansan till, perhaps to be correlated with the Albertan drift, first recognized and named by Dr. G. M. Dawson in the province of Alberta, belongs doubtless to the stage of general accumulation of the ice-sheet, followed by some recession, and then by the maximum glaciation known as the Kansan stage. Accompanying the retreat of the ice-sheet from this greatest extension west of the Wisconsin driftless area, an advance appears to have taken place east and south of that area, the ice-sheet then reaching its outermost boundary in Illinois, with encroachment on a part of the east edge of Iowa. Under this view, the Albertan, Kansan, and Illinoian stages of glaciation, fluctuating on the borders of the drift region, were probably, as geologists reckon time relations, closely consecutive. Next ensued a long interglacial stage, when the ice boundary retired so far northward as to uncover all of Iowa and the southern half of Minnesota, during probably 15,000 years, more or less, as Prof. N. H. Winchell has argued from changes of the course of the Mississippi river at Minneapolis. Afterward the greater part of the relinquished ground, reaching south to a maximum limit in the vicinity of Des Moines, was again enveloped by snow and ice. To this glaciation belong the Iowan and Wisconsin stages, again closely consecutive, the former characterized by abundant loess deposition, and the latter by the formation of prominent marginal moraines. W. U.

Geology of Southwest Missouri: Report on Greene County. By EDWARD M. SHEPARD. (Missouri Geological Survey, Charles R. Keyes, State Geologist, Vol. XII, pt. 1, Jefferson City, 1899.)

While nominally limited to a single county, so much related matter from other parts of southwest Missouri is brought in, that the Greene county report becomes in reality a key to the geology to all that portion of the state. Aside from its intrinsic value as a repository of local geological facts the account is especially valuable for two other reasons. In the first place it is intended to serve as a handbook of local geology for the geological students of Drury college at Springfield, and the preparation of the report has had this feature constantly in mind. Professor Shepard's 20 years connection with the institution, and his long experience as a mining expert and geologist for southwest Missouri has made this phase of the report such as could not be expected to be attained in any other way. In the second place the Greene county report is the first to appear of a series of similar reports that were planned and nearly completed by the late geological survey of Missouri under the directorship of Dr. Charles R. Keyes. Professor Shepard's report is then the only official document of any scientific merit, and value to mining men and geologists that is likely to appear for a long time to come.

Greene county lies upon the crest of the great Ozark dome. In this connection the origin of the name is not without interest. Quoting Featherstonhaugh it is stated that "It was the custom of the French Canadians to abbreviate their names. If they were going to the Arkansas mountains they would say that they were going 'Aux Arcs', and thus these highlands have obtained the name Ozarks from American traveiers. Springfield the chief city of southwest Missouri is exactly on the drainage divide and the waters from opposite sides of one of the principal streets flow down opposite sides of the dome. On one side they flow into the Missouri river and on the other into the White river, and each after passing half way around the great uplift meets the other again in lower Mississippi.

The description of the caves and springs and their effects upon the surface relief is especially instructive, for this is a great cave region, though as yet little known. Not in Greene county but near its boundaries are rivals to the celebrated Mammoth and Wyandotte caverns.

Of the geological formations represented in the Greene county area the Carboniferous terranes are of especial interest. They are found to be easily paralleled with those of the typical sections on the Mississippi river, in the northeastern part of the state. The full nomenclature of the type localities is adopted. For the Burlington-Keokuk limestones, which are easily separable Keyes' name Augusta in preference to Osage, is adopted, and the nominal history discussed at length in order to bring out fully the evidence for the conclusions arrived at in this locality.

Among the economic deposits lead and zinc come in for the greatest amount of consideration. Quite full accounts are given concerning the manner of occurrence of the ores, the relations of the ore bodies to the geological terranes, and the distribution of the metalliferous deposits both stratigraphically and areally. Not the least valuable feature of this part of the report is the advice regarding prospecting and developing. Much historical matter is incorporated in the descriptions of the mines.

The building stones are remarkable in that they form some of the most extensively quarried rocks in the state. Closely associated with them is an immense lime-burning industry. Some of the largest lime kilns in the country are located within the area, and the product is shipped all over the Mississippi valley. The historical data given is of great interest. The clays also are considered at length. Full mention is made of the minor deposits that are capable of being utilized.

The volume of 260 pages is accompanied by a good geological map on a scale of two miles to the inch, and by numerous good sections and half-tone plates. Professor Shepard is to be congratulated for furnishing his community with so lucid an account of its mineral resources, The report will be looked upon as a model of its kind.

MONTHLY AUTHORS' CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Barnard, E. C.

Report of the Fortymile expedition. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Beede, J. W.

New Fossils from the Kansas Coal Measures. (Kans. Univ. Quart., vol. 8, plates, 32, 33, July, 1899.)

Beede, J. W. (and Austin F. Rogers).

New and little known pelecypods from the Coal Measures. (Kans. Univ. Quart., vol. 8, plate 34, July, 1899.)

Beyer, Samuel W.

Buried Loess in Story county. (Proc. Iowa Acad. Sci., vol. 6, pp. 117-122, 1898 [1899]).

Brooks, Alfred H. (Peters, W. J. and)

Report of the White River-Tanana expedition. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Brooks, Alfred H.

The Yukon district. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Brooks, Alfred H.

The coast from Point Barrow to the Mackenzie. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Clarke, F. W.

Constitution of tourmaline. (Am. Jour. Sci., vol. 7, pp. 111-122, Aug., 1899.)

Crook, A. R.

Oliver Marcy. (Portrait.) (Am. Geol., vol. 24, pp. 67-72, Aug., 1899.)

Dumble, E. T.

Notes on the Geology of Sonora, Mexico. (Trans. Am. Inst. Min. Eng., New York meeting, Feb., 1899, pp. 31.)

Eldridge, G. H. (and Robert Muldron.)

Report of the Sushitna expedition. (Maps and Desc. of Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Eldridge, G. H.

The coast from Lynn canal to Prince William sound. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Eldridge, G. H.

The extreme southeastern coast. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

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*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Eldridge, G. H.

The Sushitna Drainage Area. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Fultz, Francis M.

The Burlington artesian well. (Proc. Iowa Acad. Sci., vol. 6, pp. 70-74, 1898 [1899]).

Hall, C. W.

Distribution of the Keewatin in Minnesota. (Science, N. S., vol. 10, p. 104, July, 1899).

Hayes, Willard C.

The Nicaragua Canal route. (Science, N. S., vol. 10, p. 97, July 28, 1899.)

Herrick, C. L.

The Geology of the Socorro mountain. (Bul. Univ. New Mexico, vol. 1, 1898.)

Herrick, C. L.

The Limitar volcano. (Bul. Univ. New Mexico, vol. 1, 1898.)

Herrick, C. L.

Mount Magdalena and the basic eruptives of the Magdalena district. (Bul. Univ. New Mex., vol. 1, 1898.)

Herrick, C. L.

The Geology of the San Pedro and the Albuquerque districts. (Bul. Univ. New Mexico, vol. 1, 1898.)

Hershey, O. H.

The age and origin of certain gold deposits in the isthmus of Panama. (Am. Geol., vol. 24, pp. 73-77, Aug., 1899.)

Hopkins, T. C.

Feldspars and kaolins of southeastern Pennsylvania. (Jour. Franklin Institute, 31 pages, July, 1899.)

Iwasaki, C.

Orthoclase crystals from Shinano, Japan. (Am. Jour. Sci., vol. 7, pp. 157-159, Aug. 1899.)

Leverett, Frank.

The Lower Rapids of the Mississippi river. (Proc. Iowa Acad. Sci., vol. 6, pp. 74-93, 1898 [1899].)

Manson, Marsden.

The evolution of climates. (continued.) (Am. Geol., vol. 24, pp. 93-120, Aug., 1899.)

Mendenhall, W. C.

Report on the region between Resurrection bay and the Tanana river. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Mendenhall, W. C.

The Kadiak islands. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Mendenhall, W. C.

The Kenai Peninsula. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Mendenhall, W. C.

The Alaska peninsula and the Aleutian islands. (Map and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Myers, P. C.

Report on a fossil diatomaceous deposit in Muscatine county, Iowa. (Proc. Iowa Acad. Sciences, vol. 6, p. 52, 1898 [1899].)

Muldron, Robert. (Geo. H. Eldridge and)

Report of the Sushitna expedition. (Maps and Desc. Routes of Alaska, 1898; U. S. Geol. Sur., 1899.)

Peters, M. J. (and Alfred H. Brooks).

Report of the White River-Tanana expedition. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Post, W. S. (J. E. Spurr and)

Report of the Kuskokwim expedition. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Prosser, C. S.

Note on the distribution of the Cheyenne sandstone. (Kans. Univ. Quar., vol. 8, July, 1899.)

Rogers, Austin F. (J. W. Beede and)

New and little known pelecypods from the Coal Measures. (Kans. Univ. Quart., vol. 8, pl. 34, July, 1899.)

Sardeson, F. W.

Lichenaria typa, W. and S. (Am. Jour. Sci., vol. 7, pp. 101-105, Aug. 1899.)

Schrader, F. C.

Report on Prince William sound and the Copper river region. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Schrader, F. C.

The Prince William sound and Copper River country. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Shimek, B.

The distribution of Loess Fossils. (Proc. Iowa Acad. Sci., vol. 6, pp. 98-113, 1898 [1899].)

Spurr, J. E.

The Noatak river. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Sur., 1899.)

Spurr, J. E. (and W. S. Post).

Report of the Kuskokwim expedition. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Surv., 1899.)

Spurr, J. E.

Lakes Iliamna and Clark. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Surv., 1899.)

Spurr, J. E.

The Nushagat river. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Surv., 1899).

Spurr, J. E.

The coast from Bristol bay to the Yukon. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Surv., 1899.)

Spurr, J. E.

The Kuskokwim drainage area. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Surv., 1899.)

Spurr, J. E.

From the Yukon mouth to Point Barrow. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Surv., 1899.)

Spurr, J. E.

The Kowak river. (Maps and Desc. Routes in Alaska, 1898; U. S. Geol. Surv., 1899.)

Stewart, Alban.

Leptichthys, a new genus of fishes from the Cretaceous of Kansas. (Am. Geol., vol. 24, p. 78, Aug., 1899.)

Stewart, Alban.

Notice of three new Cretaceous fishes, with remarks on the Saurodontidæ, Cope. (Kans. Univ. Quart., vol. 8, July, 1899.)

Stewart, Alban.

Notes on the osteology of Anogmius polymicrodus Stewart. (Kans. Univ. Quart., vol. 8, July, 1899, plate 31.)

Todd, J. E.

New light on the drift in South Dakota. (Proc. Iowa Acad. Sci. vol. 6, pp. 122-130, 1898 [1899].)

Udden, J. A.

The Pine Creek conglomerate. (Proc. Iowa Acad. Sci., vol. 6, pp. 54-56, 1898 [1899].)

Udden, J. A.

Diatomaceous earth in Muscatine county. (Proc. Iowa Acad. Sci., vol. 6, p. 53, 1898 [1899].)

Upham, Warren.

Glacial History of the New England islands, Cape Cod and Long Island. (Am. Geol., vol. 24, pp. 79-92, Aug., 1899.)

Walcott, C. D.

Maps and descriptions of routes of exploration in Alaska in 1898, with general information concerning the territory. Prepared in accordance with public resolution No. 25, of the fifty-fifth congress, third session, approved March 1st, 1899. Ten maps in an accompanying envelope. Octavo, pp. 138. (U. S. Geol. Survey, 1899.) With special reports of expeditions.

Williams, H. S.

Devonian interval in northern Arkansas. (Am. Jour. Sci., vol. 7, pp. 139-153, Aug., 1899.)

Williston, S. W.

A new genus of fishes from the Niobrara Cretaceous. (Kans. Univ. Quart., vol. 8, July, 1899, plate 26.)

Witter, F. M.

Observations on the geology of Steamboat Springs, Colorado. (Proc. Iowa Acad. Sci., vol. 6, pp. 93- 98, 1898 [1899].)

CORRESPONDENCE.

Correlation in the Ozark Region: A Correction. To the youthful student one of the most fascinating phases of geological work is the making of correlations. While passing through this early period of science study, the writer fell into several radical errors of this nature, one of which has just come to light. As I make it a point to acknowledge and correct such early mistakes in my published statements and conclusions as soon after they are discovered as convenient, I have hereby hastened to record the correction of the error of correlation referred to above. The making of it may be charged against youthful enthusiasm and inexperience.

While residing in southern Missouri, about five years since, I studied out the geologic column of the stratigraphy of Stone and Barry counties in southwestern Missouri. About at the base of the Kinderhook group and apparently under the well-marked Louisiana limestone, I found a series of shale and limestone strata of post-Ozark age, which from my wrong identification of the "Green shale" as the equivalent of the Eureka shale, I described as the Devonian series of southwestern Missouri. I reconnoitred the country from my home in Stone county, across the White River basin to Eureka Springs, in Arkansas, and traced the prominently outcropping layers of the Louisiana limestone to that town, where they seemed to be separated from the Lower Magnesian or Ozark series by the "green shale" only, no exposures of the true, black Eureka shale coming within my field of observation; hence my grave error of correlation.

Recently I have retraversed the territory, and have seen the real Eureka shale not only under the "Green shale", but under my entire so-called "Devonian series" except the basal conglomeratic sandstone. The Eureka shale is black in color, thinly laminated, and radically different in lithologic character from anything in the Lower Carboniferous strata. At Eureka Springs, I found it eight feet thick, but farther west in Benton county, Ark., and McDonald county, Missouri, it is reduced to a scarcely noticeable layer of soft, shaly material, two or three inches in thickness. Wherever seen, its upper limit is sharp, there being an extremely sudden change from the black shale to the gray limestone.

Under the black shale is, at Eureka Springs and throughout that section of northern Arkansas (as described in the Arkansas geological reports), a bed of sandstone generally several feet in thickness, which constitutes the lower member of the Devonian. It is known as the Sylamore sandstone. It is this same formation, reduced to a thickness of two inches to one foot in the section of Stone and Barry counties, Missouri, specially studied by me, that is the "Basal Conglomeratic Sandstone" of my so-called "Devonian series."

Over the Eureka shale, at Eureka Springs, Ark., is the so-called "St. Joe marble," the Arkansas equivalent, in part at least, of the Louisiana limestone or basal member of the Kinderhook group of Missouri. This is commonly described as a unit, but is properly made up of four quite distinct members which in Stone county, Mo., may be described as the heavy bedded, gray Louisiana limestone proper, 20 feet thick; the green shale, 7 feet; the fossiliferous brown shaly limestone, 10 feet; and the speckled crinoidal limestone, 3 feet. These are all present at Eureka Springs, Ark., but the three last are much reduced in thickness, less distinct in character, and have not received the attention which they deserve.

I wish to take advantage of this letter to remark that the persistency of the geological students of the lead and zinc district of southwest Missouri to set up and maintain an independent local classification of the rocky strata of this region is hardly called for. The "Cherokee" limestone of their classification is, beyond doubt, the equivalent of the Augusta (Burlington and "Keokuk") of Iowa and Illinois, and the "Boone" chert, with the "St. Jo marble" added, is with equal certainty the practical equivalent of the Kinderhook group of the Iowa-Illinois district. These facts have been known for years, yet even to-day Joplin mining geologists will contend that such correlation is so doubtful that they are justified in setting up their own system of nomenclature.

In conclusion, to rightly fix my relation to the study of the stratigraphy of southwest Missouri, I will give a column of the strata in Stone and Barry counties, including the Eureka Springs district, as follows:

1.	Coal Measure sandstone, conglomerate and a little shale.	50 feet
	Marked erosion and non-conformity.	
2.	Augusta, crinoidal limestone.	50 feet
3.	Heavy bedded, sometimes magnesian, argillaceous, brown limestone (Kinderhook).	30 feet
4.	Shaly limestone, greenish, calcareous shales and heavy chert layers (Kinderhook shale proper).	130 feet
5.	Hard, evenly bedded, gray, sub-crystalline limestone (Louisiana proper).	20 feet
6.	Green, thinly laminated, non-fossiliferous shale.	7 feet
7.	Fossiliferous, brown, shaly limestone (part of St. Joe marble of Arkansas).	10 feet
8.	Evenly bedded, speckled (brown and white) crinoidal limestone.	3 feet
9.	Black Eureka shale.	8 feet
10.	Yellowish Sylamore sandstone (with characteristic black quartz grains).	4 feet
11.	"Cotton-rock" and sandstones of Ozark series.	200 feet

Numbers 3 to 8 inclusive are, beyond any reasonable doubt, the exact equivalents of the Kinderhook group of Iowa and Illinois, become less shaly and more highly calcareous and cherty toward the southwest from their type locality. Also, if lithology may have any weight in classifying strata, numbers 9 and 10 are distinct from the Lower Carboniferous series and may be considered as Devonian in position, if not age.

As my studies in stratigraphy become more advanced as the years go by, I am more inclined to place dependence on lithology and (within certain limits) less on paleontology, in making correlations. The only truly safe way of identifying formations is by actually and faithfully tracing them across country from outcrop to outcrop, noting the changes which they undergo, and their relations to the strata above and below. When this is done the correlations rest on a basis which no amount of paleontological evidence can weaken. It is because of the contradictory nature of the paleontological evidence that the Joplin mining geologists refuse to accept the extension of the Iowa-Illinois nomenclature to their district but this correlation rests upon actual tracing work and has a sound basis.

Galena, Mo., Aug. 24, 1899. OSCAR H. HERSHEY.

IS THE SO-CALLED "UPHEAVAL OF SCANDINAVIA," APPARENT OR REAL? When Celsius in 1730, offered the suggestion that the observed rising of the Baltic shores was due, in fact to a real subsidence of the waters of the Baltic, he encountered a storm of opposition.

Leopold Von Buch about 1610 attributed the rising of these shores to the actual upheaval of the land, assuming the sea level to be an invariable plane of reference.

Von Buch's decision at this time, in so far as I can learn, has never been questioned; on the contrary universal acceptance has been granted to his theory, and the upheaval of Scandinavia has consequently entered into the science of Geology as a type—a living representative of that slow growth of continents—that gradual uplifting of mountain ranges, by which geology, under the theory of a cooling and wrinkling globe, would explain all rugosities of the earth's surface.

Now I believe that good and sufficient reason exists for a reconsideration of this entire question, and I would offer in favor of the theory of Celsius and in opposition to that of Von Buch, the following discussion, believing the argument contains matter worthy of more complete study.

Mr. William Ferrel, well-known for his mathematical discussions of tides and tidal influences, has shown (Science, Vol. 7) that the oceanic waters are now piled up against the coasts of Europe owing to the impulse of the gulf stream, which is continually pushing its waters against these shores. He says (page 76):

"For instance in the North Atlantic the tendency to flow eastward in the middle and higher latitudes, causes a slight heaping up of the water, and a rise of surface level adjacent to the coast of Europe, and a drawing away of the water and a depression of sea level along the northeast coast of the United States."

He then gives a table of gradients showing the slope of the ocean's surface under this deforming influence. This table gives the gradient at each 10 degrees of latitude from the equator to the poles.

Ferrel says again (page 76):

"From this table it seems that a velocity of four miles per day of the water of the upper strata toward the pole, in the latitude of 45°, would cause a gradient of about 0.36 of a foot in 100 miles, or about 10 feet between New York and Brest, in case of a static equilibrium. But of course for reasons already given, there would not be really this difference—perhaps only about half of it; but this would be sufficient to account for the observed differences of sea level between Brest and Marseilles, and the gulf of Mexico and New York harbor; the surface of the ocean adjacent to the coast of France being about 25 feet above mean level, and that adjacent to New York as much below." (While I have quoted Science correctly as 25 feet, it is plain that this amount should be read as 2.5 feet.)

This computation it will be seen, is based upon the assumption that the gulf stream strikes the coast of Europe with a velocity of 4 miles in 24 hours. From such data as I have been able to gather, however, it seems certain that the velocity must be at least double the above amount, or about 8 miles per day.

The "current chart" of the north Atlantic, No. 1308 U. S. Hydrographic Bureau, shows the velocity of the stream off the southwest coast of Ireland as 8 to 24 miles per day, while in latitude 55°-55° 30' W. the velocity of flow is given as 10 to 24 miles per day.

I therefore conclude that the surface of the ocean adjacent to Europe must be at least five feet above, and that adjacent to New York, five feet below the mean or normal surface of the geoid.

Ferrel's position in this matter, as I have previously demonstrated, is sustained by the facts of observation, for instance:—

The gulf of Mexico is 41 inches above the mean sea level at New York. (Smithsonian Contrib., 1891, page 196). (Science, Vol. 3, page 504.)

The gulf of Mexico is 3.75 feet higher at the mouth of the Suwanee river than is the Atlantic at the mouth of the St. John's river, both of these in Florida. (Penny Ency., Vol. 21, page 148, Pearson.)

The mean sea level of the North sea and the Atlantic at Amsterdam and Brest is found to be from 2 to 5 feet above that of the Mediterranean at Marseilles and Trieste, a result, "which is not easy to explain on mechanical principles." (Ency. Brit., Vol. 22, page 708.)

Bourdalone says that the mean level of the Red sea at Suez exceeds by 31½ inches, that of the Mediterranean near Port Said. (Reclus, "Ocean," page 33.)

The Ency. Brit. (Vol. 22, page 708), says these seas are "identical" in level, and in another volume it directly contradicts this alleged identity of level by saying (Vol. 4, page 792) "We always found a current running northward from lake Timseh at the rate of from half a mile to a mile an hour."

This contradiction arises from the fact that the tides in that portion of the Mediterranean are known to be but 8 inches, while in the Red sea they range from 5 to 6 feet, twice every day; therefore, if the levels were identical, the waters of the canal should run towards the south, the sea level being then from 2 to 3 feet lower in the Red sea than in the Mediterranean, but as these waters do not show this change, we conclude that Bourdalone is right; the mean level of the Red sea is beyond dispute somewhat in excess of 2½ feet above that of the Mediterranean.

Now then, if we can place confidence in Ferrel's computation, these ocean currents must necessarily elevate the sea level wherever they impinge on a coast line, and depress the same wherever they flow away from a coast line. I have also shown that these elevations and depressions have actual existence, and that the observed deformations of the sea level agree with the mathematical demands of Ferrel's table, so far as our knowledge of the velocity of flow will enable us to judge.

Does it not follow, then, if from any climatic or other cause the gulf stream, for instance, should decrease slightly in its flow, that there should be a fall of sea level on all those coasts where the deformations had been plus, and a rising of sea level on those shores where the deformations had been minus? In other words, if these ocean currents should decrease in their velocity of flow, Scandinavia, Spitzbergen, Bab-el-Mandeb, arctic Russia, Alaska and Texas would immediately enter upon an epoch of apparent upheavel, while New Jersey, New York and the American coast generally, from North Carolina to Greenland, should enter upon an epoch of subsidence.

Now we know that these theoretical upheavals and depressions, exactly as our assumption demands, are a matter of record; we might be allowed to infer therefore that these contemporaneous changes in the sea level, up here, down there, precisely according to law, are, when properly interpreted, merely proof almost incontestable, that when M. Babinet said "We may boldly affirm that the current passing around North cape is lessening" (Smithsonian Rep., 1869, page 291) he was making a statement which seems now to be supported by testimony of a more satisfactory nature than that on which he based his original conclusion.

My contention is then, that when men of science, without exception, have attributed these changes in sea level, to the upheaval or depression of the solid earth, there is a strong probability that they were in error, and that Huxley's dictum,—"It is therefore absurd to assume a rise (of the sea level) in one place and a fall in another at the same time" (Physiography, page 211) is not well founded, and is opposed to the principles of hydro-mechanics.

In explaining these so-called upheavals and depressions by a motion of the earth's crust, we can understand, even if we do not accept, the contention of geologists, that contraction by cooling will cause this upheaval, but neither we nor they can understand how this cooling will produce the subsidence; they therefore, to explain this latter phenomenon, appeal to the unknown and the supernatural. Some philosopher has said "exhaust all known processes before appealing to the unknown, in explanation of observed facts."

In these ocean currents, there is a known cause for all these heretofore unexplainable occurrences; the difference in level, between the North pole and the Mediterranean, is easy to explain on "mechanical principles;" where we find elevation in one place contemporaneous with a fall in another, these observation may be foretold by law.

If decrease in the gulf stream however, can explain the upheaval of Scandinavia, it is admissible to inquire from whence can this variation in flow be derived. In reply to this it can be said that the origin of the gulf stream is still a subject of dispute. Maury urges difference in specific gravity of ocean waters, as the cause; Carpenter alleges difference in temperature, expansion by heat and contraction by cold; others invoke excess or absence of saline contents from greater or less evaporation; Dr. Croll calls on the trade winds; Catlin uses subterranean rivers discharging into the Caribbean sea from the Andes and the Rocky mountains, but when we examine these supposed sources, we find every one to be a function of climate; any change in climate produces a variation in heat, expansion, evaporation, trade winds and rivers; therefore, no matter which of the above reasons may be accepted as the true cause of being of this stream, it follows that any variation in climate will produce a corresponding variation in these oceanic currents. We therefore, have merely to seek evidence of change in climate, and if this be found we have perfect right to decide that contemporaneous with this change there must necessarily have existed a variation in flow of the gulf stream, and consequently an apparent rise of some shore lines and a depression of others.

We will now touch upon this matter of change in climate. Elsewhere I have shown that during the historic period there have been such changes, and that the period of vibration has been about 640 years, confused, however, by minor periods of shorter duration; but to bring in all the data I have accumulated on this subject, is impossible here. I quote however, sufficient to establish the fact that there has been variation of climate in recent times.

In 1561 "the vintage took place at hights of 2,000 feet on the mountains of Vivarais, where in the present century the vine no longer bears fruit," ("Ocean," Reclus, page 353).

M. Kerner estimates the retreat of the forest vegetation on the Alps and Carpathian mountains, as over 300 feet in vertical elevation, during the last two or three centuries. (Ocean, p. 354.)

"Direct thermometric observations have proved that for a century the cold has slightly increased at various places in Germany." ("Ocean," page 354.)

"Iceland and eastern Greenland have become much colder since the fourteenth century." ("Ocean," page 355.)

The southern part of the Baltic was completely frozen over in the years 1323, 1333, 1349, 1399 and 1402. ("Ocean," page 57.)

M. Venetz says before the 10th century, the Swiss glaciers were larger than now, and after retreating for four centuries, they have been slowly acquiring their former dimensions. (Lyell's "Principles," 11th, Vol. I, page 277.)

For a great mass of testimony as to changes in climate during the last two thousand years, consult Mr. W. H. Larabee's article "Variation in Climate," in the Popular Science Monthly, April, 1872.

But perhaps the strongest argument in favor of these slow climatic changes extending over periods of many centuries, is found in the history of the Aralo-Caspian basin.

During the historic period, the surface of the Caspian has stood at times, 60 feet above its present level, as well as 28 feet below. (See "The Earth and its Inhabitants—Asia," Vol. I, p. 10.)

The Oxus has certainly alternated its discharge between the Aral and the Caspian three times in the last two thousand years, and there is no possible explanation of these circumstances, except by invoking great changes in the climate of the Caspian basin, at the same time requiring the existence of these different conditions during periods of several centuries.

These items should demonstrate that the climatic changes necessary to the variation in flow of our ocean currents, have real existence, and the fact that these changes have been so slow as to almost escape recognition impairs the evidence not in the slightest, when the problem has once been entered upon.

I will admit that Von Buch's explanation of these upheavals and subsidences now forms one of the very foundation stones of modern geology, and that to attack a principle that has been a matter of belief for nearly a century, may seem absurd and ridiculous, but nevertheless, these old beliefs are entitled to only such measure of respect and consideration as may be warranted by the facts on which these beliefs are based. No strength has been added to Von Buch's doctrine by reason of its long continued acceptance. Other theories—theories that have been accepted for a thousand years—we have been forced to discard before now, and I believe we must discard in its turn this theory of Von Buch, a theory founded on bare inference, unsupported by a single fact, and replace it with a theory founded on observation, and on known physical principles.

Duluth, Minn., January 20, 1899. H. W. PEARSON.

PERSONAL AND SCIENTIFIC NEWS.

THE WYOMING EXPLORING PARTY. The expedition to the fossil fields of Wyoming left Omaha on July 18th. It numbered three hundred scientific gentlemen, representing nearly every university and college in the United States. The Union Pacific Railroad company pays all the expenses of the trip, and it is hoped that the expedition will result in developing the possibilities of this great region which is so rich in fossils of the Dinosaur period. After reaching Laramie the party will go directly into the fossil fields. They will be organized into messes of ten men, each group being provided with two wagons for riding and another wagon for carrying tents, provisions, and other supplies. A dark room and a complete photographic outfit will be provided. Prof. Wilbur C. Knight, of the University of Wyoming, will have charge of the party. It will take one course to the grand cañon of the Platte, and will return by another course, giving an opportunity for viewing some of the finest scenery in the West, and also giving a chance to collect great quantities of vertebrate fossils.—*Scientific American*, July 29.

MEETINGS OF THE AMERICAN ASSOCIATION AND THE GEOLOGICAL SOCIETY. The forty-eighth annual meeting of the American Association for the Advancement of Science has just been held in Columbus, Ohio, under the presidency of Dr. Edward Orton, from Monday to Saturday, August 21st to the 26th. About 350 members and associates were in attendance, and large series of papers were presented in each of the sections. Their sessions were held in the buildings of the Ohio State University. More than a hundred new members were elected, including a large representation from the city of Columbus.

In section E (Geology and Geography) Dr. J. F. Whiteaves, of the Geological Survey of Canada, was vice-president, and Prof. Arthur Hollick, of Columbia University, New York City, secretary. The vice-presidential address by Dr. Whiteaves, on "The Devonian in Canada" was given at two o'clock on Monday afternoon; and in the evening the retiring president, Prof. F. W. Putnam, gave an address in the Board of Trade Auditorium, which was followed by a reception to the members and guests of the Association.

On Tuesday, the 22d, the Geological Society of America held, in joint session with section E, its eleventh summer meeting, Prof. B. K. Emerson, being the president, and Prof. H. L. Fairchild secretary. Nine other societies, affiliated with the American Association, also held meetings in Columbus during or immediately preceding the general Association meeting.

The list of papers presented before section E and the Geological Society, in their order on the daily program was as follows:

The Geology of Columbus and vicinity. Edward Orton, Columbus, Ohio.

Glacial Phenomena of Central Ohio. Frank Leverett, Denmark, Iowa.

Glacial and Modified Drift in Minneapolis, Minn. Warren Upham, St. Paul, Minn.

Lateral Erosion at the Mouth of Niagara Gorge, G. Frederick Wright, Oberlin, Ohio.

The Geology of Oahu, Hawaiian Islands. Charles H. Hitchcock, Hanover, N. H.

A pre-Cambrian-Upper Algonkian Terrane. Charles D. Walcott, Washington, D. C.

The Petrographic Province of Fox River Valley, Wisconsin. W. H. Hobbs and C. K. Leith, Madison, Wis., with analyses by W. W. Daniels.

Age and Development of the Cincinnati Anticline. August F. Foerste, Dayton, Ohio.

The Lower Devonian aspect of the Lower Helderberg and Oriskany formations. Charles Schuchert, Washington, D. C.

The Silurian-Devonian Boundary in North America. Henry S. Williams, New Haven, Conn.

The Section at Schoharie, N. Y. John J. Stevenson, New York City.

The Ozarkian and its Significance in Theoretic Geology. Joseph LeConte, Berkeley, Cal.

Geological Results of the Indiana Coal Survey. George H. Ashley, Indianapolis, Ind.

The Cape Fear Section in the Coastal Plain. J. A. Holmes, Chapel Hill, N. C.

The Occurrences of Corundum. J. H. Pratt, Chapel Hill, N. C.

Triassic Coal and Coke of Sonora, Mexico. E. T. Dumble, Houston, Texas.

Some Geological Conditions favoring Water Power developments in the South Atlantic region. J. A. Holmes, Chapel Hill, N. C.

Paropsonema, a peculiar Echinoderm from the Intumescens Fauna, New York; Remarkable Occurrence of Orthoceras in the Oneonta Sandstones of New York; The Squaw Island "Water Biscuit," Canandaigua Lake, New York. John M. Clarke, Albany, N. Y.

The Pot Holes of Foster's Flats (now called Niagara Glen) on the Niagara river. Miss Mary A. Fleming, Buffalo, N. Y.

A Consideration of the Interpretation of Unusual Events in Geological Records, Illustrated by Recent Examples. Frederick W. Simonds, Austin, Texas.

The pre-Lafayette (Tennessean) Baselevel. W J Mc Gee, Washington, D. C.

The Relative Ages of the Maumee Glacial Lake and the Niagara Gorge. Charles E. Slocum, Defiance, Ohio.

The Galt Moraine and Associated Drainage. F. B. Taylor, Fort Wayne, Ind.

Discovery of New Invertebrates in the Dinosaur beds of Wyoming. E. H. Barbour and W. C. Knight, Lincoln, Neb.

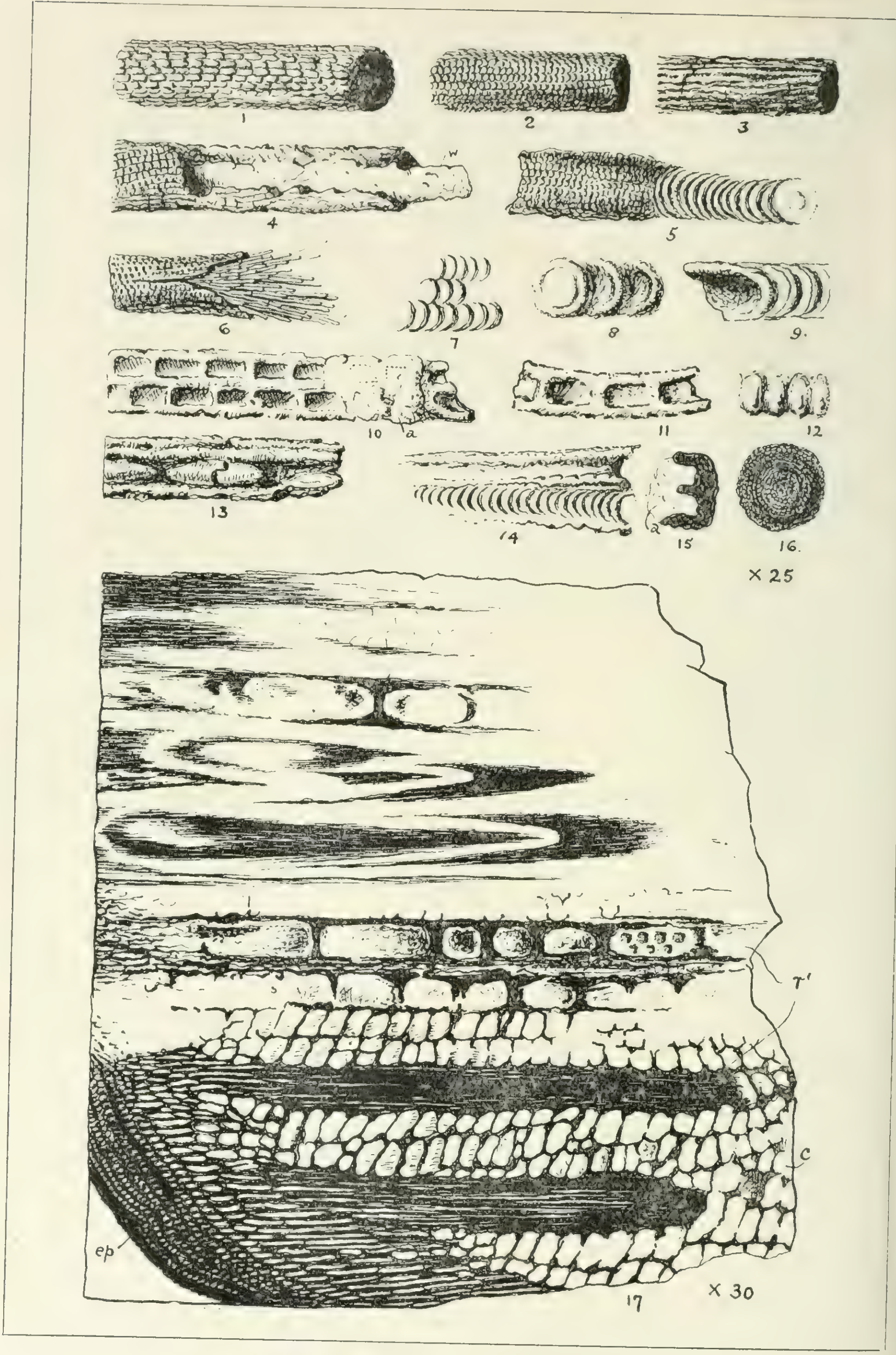
The Rapid Decline of Geyser Activity. E. H. Barbour, Lincoln, Neb.

Greatest Area and Thickness of the North American Ice-sheet. Warren Upham, St. Paul, Minn.

Several papers read in other sections, notably that of Anthropology, on the prehistoric existence of man on this continent, were also important in their relations to geology.

On Thursday the geologists held no session, but occupied the day in an excursion to Lancaster, Ohio, for the examination of the glacial drift and older formations, and especially to see the natural gas wells near Lancaster. Longer excursions, including examination of groups of aboriginal mounds, were taken on Saturday.

The president elect for next year's meeting is Prof. R. S. Woodward, of Columbia University. The vice president of section E, elected for that meeting, is Prof. James F. Kemp, of the same university, and its secretary, Prof. J. A. Holmes, of the University of North Carolina, Chapel Hill, N. C.



STRUCTURES IN COAL. (The 'Rod-Plant'.)

THE

AMERICAN GEOLOGIST.

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POSSIBLE NEW COAL PLANTS IN COAL.

By W. S. Gresley, F. G. S., F. G. S. A., Erie. Pa.

(Plates VII, VIII, IX, and X.)

In "Side-Light upon Coal Formation" in the February (1899) number of the American Geologist, the very common occurrence in coal-beds, of coal bodies resembling rods, was enlarged upon and illustrated (plate ii). It is now my desire to present evidence obtained from studying coal—anthracite in particular—showing the organic connection between the rods and the enclosing or surrounding tissues, evidence in fact enough to make it probable that the plant to which these rods, or some of them, belong, is now revealed, and is apparently one whose description has not hitherto been published.

Figs. 1 to 16, plate VII, show portions of rods somewhat similar to those figured in this magazine as above referred to. Now, in fig. 17, pl. VII, we see rods, differing in structure from one another, organically connected to a zone or layer composed of dense cells of small diameter and of considerable length. Herein is also evidence of the organic contact of the cellular material separating the rods, with the denser layer; in fact both the rods and the inter-rodular material are seen to merge into the same compact fribro-cellular layer or "rind." I call this layer or zone the rind, for the reason that in all the very numerous specimens I have examined, I have never detected the semblance of anything indicating growth or extensions beyond it, if the exception in fig. 21, pl VIII, where this dense layer seems to be putting forth a shoot or sprout, be allowed. It will be observed that the trend of the tissues in contact with or growing out of the rods is always parallel with the rods. Another point is that so far no specimen has turned up which reveals anything anatomically suggestive of rays, or offshoots in connection with the structures observed as pertaining to the rods, save the possible exception just mentioned.

A special interest surrounds the specimen whose longitudinal section is seen in fig. 25, pl. VIII. From a very careful examination of the lump of anthracite that contained this fossil it was evident that the entire specimen was embedded in it; the object is therefore not a fragment of the specimen because it did not reach the surface of the piece of coal. Another reason for concluding that in this specimen (fig. 25) we have an entire individual, is the fact that the same piece of coal contained other very similar specimens of the same plant, but owing to the obduracy of the material none of them were secured or so satisfactorily fractured for examination as this one was. These individual fossils may be said to have been enclosed in the coal just as almonds are in a cake, but in the coal they lay parallel with the grain or bedding planes. So that whatever this is, it is not a fragment in the sense that it is only a portion of the original individual. Fig. 20, pl. VIII, shows a transverse view of the general structure of this specimen.

The smallness of this specimen (note the size of the rods as compared with those figs. 1 to 17, pl. VII.) shows it to be a young plant; and since it contains all of the essential characteristics of the structures observed in other specimens of the same plant possessing much larger rods, etc., the reasonable inference is that the matured individuals did not differ in kind or variety of elements and tissues, but merely differed as to their outward forms and dimensions. I presume that as the rods progressed in growth they also developed changes and differences in structure. That this plant may have possessed lobes or expansions, notwithstanding no signs of anything, approaching branches, roots, etc., is known, is reasonable to suppose. That all these observed rods belonged to such form as this is altogether too much to presume, for many of them would indicate vegetable structures referable to much higher types of plant life than the material we are considering suggests; for instance in some of the rods we are reminded of resin ducts traversing woody tissues, referable to large erect-growing plants, whereas the form under notice would indicate one of horizontal growth, worming itself about in marsh or lake. Since rods are the characteristic feature of the plant, and as they led to its discovery, I concluded to name it the "Rod plant" until a better or more botanical name be found for it or until its alliance with some known plant can be shown.

The forms of vegetable remains, illustrated in plates IX and X, which, by reason of the snake-like markings that fractures of them commonly reveal, I provisionally term the "snake-spotted plant," are very much less numerous than the "Rod-plant." While not unlike the latter in possessing two zones of quasi rods, this form fails to show so decided a rind or epidermal structure, and interrodular tissue. (See fig. 25, c c c). We must hope for better material in this connection.

Of course, like the so-called "rod-plant", exception may be taken to regarding this one as a plant; but reasons why it may be so considered are these:—(a) No specimens of it have revealed anything in the shape of rays, root, or branching processes, etc. (b) No further material or structure has been found attached to the exterior of its supposed rind, "ep" in the figures. (c) The general resemblance of form to that of the rod-plant; and (d) The fact that in fragments of the coal which enclose other individual specimens of the same thing, (see upper end of fig. 31) these appear to be independent and separate.

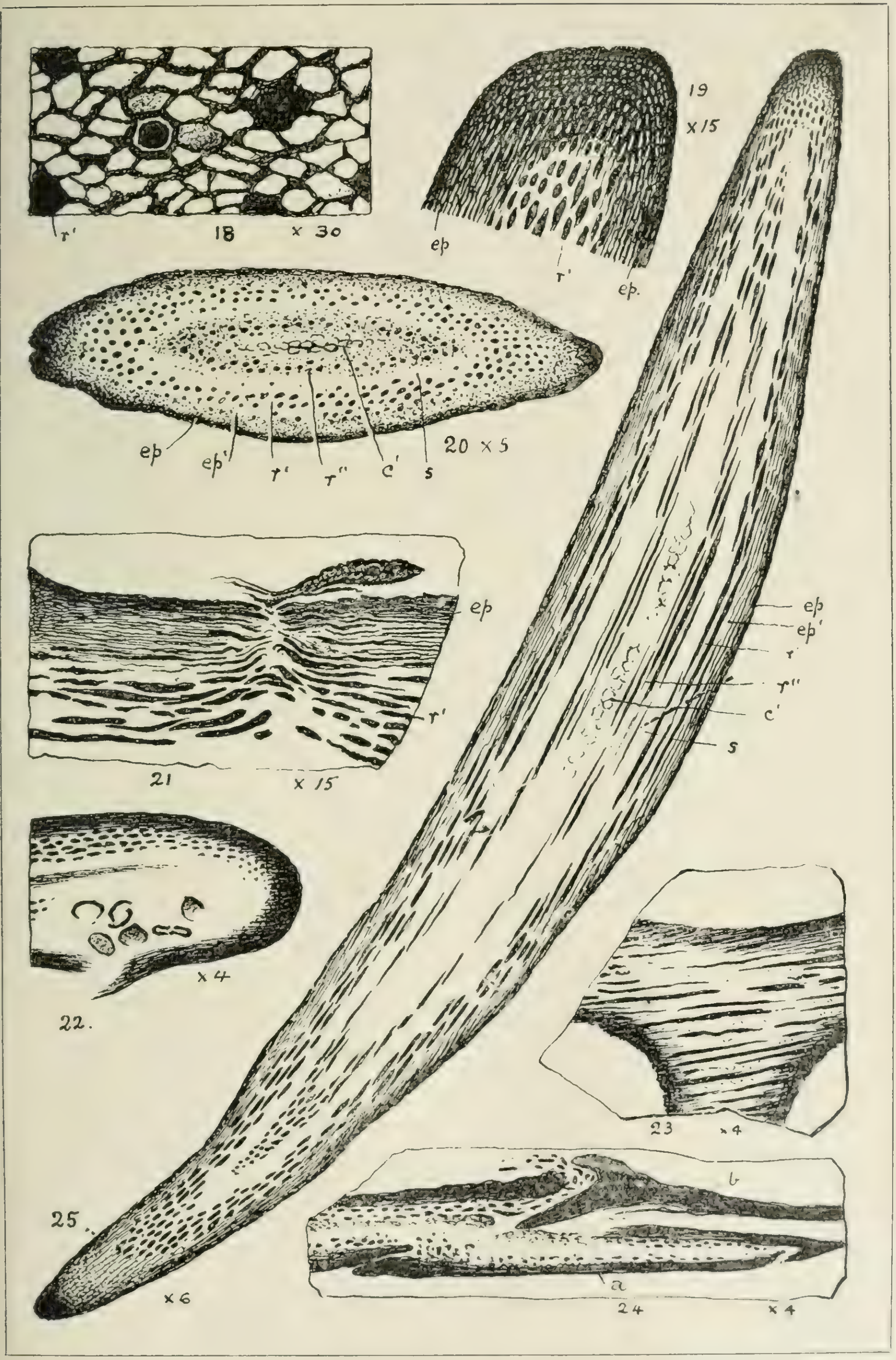
It is not my wish to stretch, by imagination or otherwise, these imperfect representations. After careful search however in the standard works of Williamson, Carruthers, Dawson, Seward, and others, I have failed to recognize in their figures or descriptions any of these anatomical structures, and cannot but feel bound to regard them as vegetable remains of sufficient importance to deserve recognition as something, if not new at least requiring further investigation. If therefore paleobotanists who may see my drawings, will kindly oblige the writer and the editor of this magazine with their views or criticisms as to the validity of these interpretations, and will state where and by whom such structures have already been published (if it is considered that they have been), it would be a favor to the author of this paper, as well as a benefit to science which would be appreciated.

It is to be regretted that so far, transparent sections of anthracite containing fossils have been impossible to make; moreover all attempts to bring out structures in it, by polishing, have failed. All of the structures noted by me have been obtained by viewing the coal as opaque material. Having obtained the most satisfactory specimens from anthracite of the somewhat dull and more distinctly laminated grades, I will suggest that intending workers would do well to pay more attention to it than to the more dense black or less streaked lumps.

It should be understood that the material of which the rod plant and the snake-spotted plant are composed is true coal—just as much as is the matrix enclosing them; and they are so thoroughly part and parcel of each other, physically, that I have never been able to expose or free any portion of the outer surface of a specimen of the rind from the matrix, in order, if possible, to ascertain the appearance of the fossil's exterior. My experience with the material of the rod plant is that bituminous coal affords the best means of getting at and studying the rods per se, while anthracite enables one to better examine the tissues surrounding the rods as well as the plant's rind, its outline, and the way in which it occurs in the surrounding coaly medium. It should also be stated that nothing has been accomplished in the way of illustrations by photography. Specimens of the fossils have been submitted to experts for experiments in this way, but all of them say nothing satisfactory could be obtained owing to the blackness of the coal or the impossibility of obviating the reflected light upon the shining and uneven surfaces of the fractures carrying the objects required to be photographed.

Reference to Plates VII and VIII.

Figs. 1 to 14. External and internal views of "rods" composed of compact, lustrous and duller coaly materials, occurring as scattered fragments, or in situ, upon the bedding-planes of coal. Fig. 4 shows a core of milk-white, brittle substance: fig. 10 a mass of clear (?) am-



STRUCTURES IN COAL. (The 'Rod-plant.')

brite filling chambered cells in rods; fig. 13 possesses a row of elongated globular masses of pale (?) ambrite or white material; fig. 6 shows a ruptured rod with its fibrous contents crushed vertically.

Hors. "Pittsburg" and "Redstone" coalbeds of bituminous coal.

Loc. Scott-Haven, Pennsylvania, U. S. A. Mag. about 25 times.

Figs. 15 and 16. Transverse section of rods as above; fig. 15, exhibiting (?) ambrite-filled chambers or channels; fig. 16, the fibrous contents, as in fig. 6.

Fig. 17. Oblique to longitudinal section, showing peripheral structure ep, merging inwards into rods r′, of various structures, separated by interrodular cellular material c.

Hor. "Mammoth" seam of anthracite.

Loc. Lehigh region. Luzerne Co., Pa., U. S. A. Magnified 30 diam.

Fig. 18. Transverse section of rods and interrodular material, r′ and c fig. 17. Lehigh Anthracite, Pa. Magnified 30 diam.

Fig. 19. Oblique section of rod-plant terminal belonging to specimen, fig. 25. ep. is the peripheral material, and r′ the outer zone of rods. Magnified 15 diam.

Fig. 20. Transverse section (restored) of the rod-plant, showing central cellular area c′; inner rod zone r″; obscure portion s; outer series of rods r′; more open tissue of coating ep′; and very dense exterior ep.

Fig. 21. Section of a portion of the peripheral tissure ep, and its accompanying zone of rods r′, displaying rupture of the former, in touch (?) with which is a sprout—or bud-like form c or (?) a seed-vessel upon the exterior.

Hor. "Mammoth" seam (of anthracite).

Loc. Luzerne Co., Pa., U. S. A.

Magnified 15 diam.

Fig. 22. Oblique section of portion of a rod-plant, showing rupture in the rind, and a group of (?) spores or (?) macrospores within the specimen. In Lehigh anthracite, Pa.

Fig. 23. Longitudinal section of part of the rod-plant, showing some of the rods r′ series, of figs. 17 and 20, extending from peripheral zone through the cells (c′, fig. 17) on to same zone.

Hor. (?) "Mammoth" seam of anthracite.

Loc. Shamokin, Carbon Co., Pa., U. S. A.

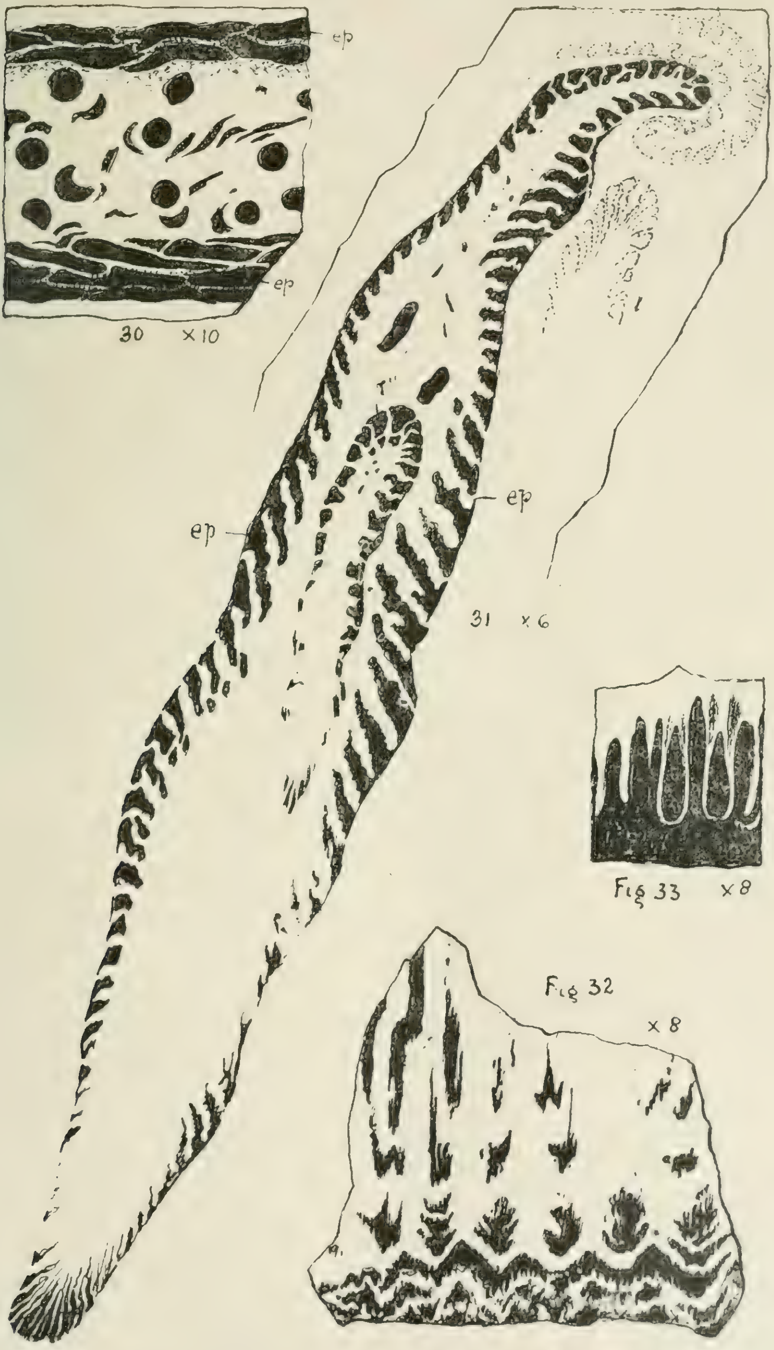
Magnified 4 diam.

Fig. 24. Oblique longitudinal section of a "rod-plant," a, thrust into by some other plant, b, so that some of the rods, etc., have been ploughed up and forced outwards into the groundmass. The rind has also been ruptured in other places.

Horizon. (?) The "Mammoth" seam of anthracite.

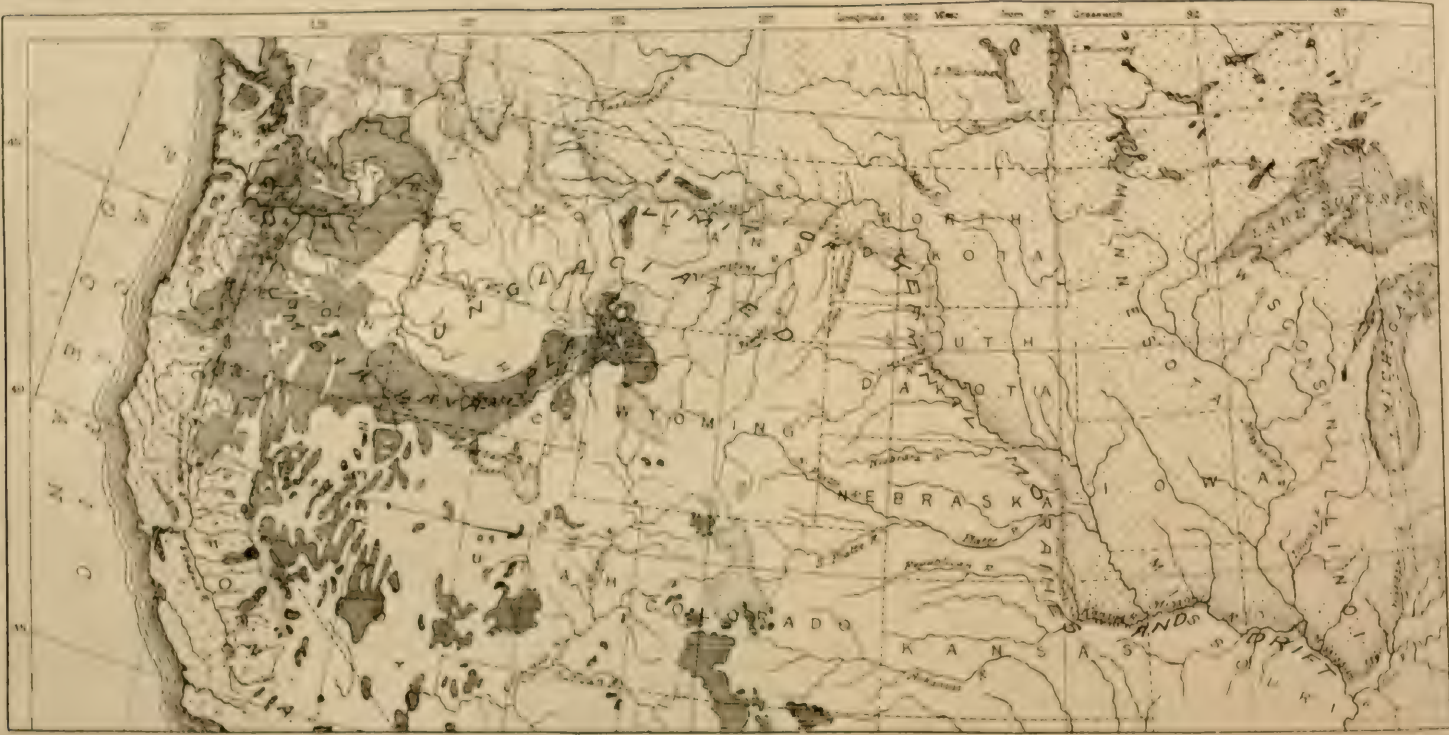
Loc. Lehigh, Pa.

Fig. 25. Longitudinal section of a supposed entire individual rod-plant, showing peripheral zone ep, ep′; outer rod-zone r′; obscure region s; inner rod-zone r″; and central cellular part c′.



STRUCTURES IN COAL. (The 'Snake-spotted' plant.)

Plate XI


Longitude 102 West from Greenwich
92
87
N O R T H
D A K O T A
S O U T H
D A K O T A
W Y O M I N G
N E B R A S K A
I O W A
K A N S A S
C O L O R A D O
U T A H
M I N N E S O T A
W I S C O N S I N
I L L I N O I S
M I S S O U R I
LAKE SUPERIOR
LAKE MICHIGAN
GLACIATED
UNGLACIATED
SANDS
DRIFT
Nebraska R.
Platte R.
S. Platte R.
Republican R.
Arkansas R.
O C E A N

THE EVOLUTION OF CLIMATES.

By Marsden Manson, San Francisco, Cal.

(Concluded from page 180.)

(Plate XI.)

Appendix.

The Columbian Lava Plain and its Climatic Influence.

The Columbian lava plain occupies portions of the slopes of the Rocky, Sierra, Warner, Butte and Cascade ranges of mountains, and of the intervening valleys and plains. This lava-covered area is exceedingly broken and lies in the states of Washington, Oregon, Idaho, Wyoming, Nevada, and California, and is about 200,000 square miles in area. Its greatest length from the headwaters of the Big Horn river in Wyoming to the base of the Coast range in Oregon, is through 15° of longitude; and its greatest width is through 9° of latitude. It is interesting to note that the fractures from which this vast outburst occurred lie about the median line of the extreme limits of the North American land mass, and that about 180° from these fractures similar fractures occurred near the median line of the Euro-Asian land mass, giving rise to the great Deccan lava plains of India. The maximum thickness of the Columbian lava is known to be 4,000 feet, and many miles of this thickness can be observed. Vertical sections of marked distinctness can be studied in the cañons of the Columbia river and its tributaries, and in the rifts known as Grand and Moses coulées. The aggregate length of deep river cañons and deep coulées which can be observed is several thousand miles, so that opportunities to study the formation and character of the lava are remarkably good.

The sections are made up of as many as thirty successive layers of lava superimposed with varying intervals of time, as the joints are sometimes very distinct with no evidences of denudation nor sedimentation, and again contain hundreds of feet of fossiliferous strata. The layers are rarely over a few hundred feet thick and overspread subdivisions of the total area sometimes at close and sometimes at widely separated intervals. During these intervals the life of the period migrated back and forth over the cooling surfaces, and was destroyed or forced to migrate by fresh deposits of lava. These migrations are very noticeable in central Washington where fossils assigned to the Miocene period are abundant. These fossils are distinctively akin to Tertiary species, but as much so to modern. They are confined to migratory types of life; the marked and significant absence of non-migratory types, and the abundance of those types capable of so escaping, together with the equal similarity of the fossils so far found to modern species, cause the writer to doubt the correctness of assigning this group of beds to the Miocene period.* The same class of evidence which would assign them to the Miocene would also assign them to a much more recent period.

Traces of volcanic heat yet remain, as is evidenced by the existence at numerous localities throughout the area of hot springs, fumaroles and heated earth. In the Yellowstone park are several thousand vents for hot water, gases, and boiling mud.

The vents from which these vast inundations escaped are not known. Although numerous extinct craters exist in the area, the slopes of the lava plain are such as to preclude the view that these were the main sources. The main outflow must have been from vast rifts now concealed, or at least undiscovered. Irregular and unequal movements of the crust have occurred since the outflow, so that the present slopes do not always coincide with those of the flowing lava.

The character of the lava varies in successive layers and in different localities. In some instances it is so soft that it can be cut with a knife, and in others is a compact, brittle, and columnar basalt. In some instances this lava sheet directly overlies Tertiary formations.

In its more elevated portions, particularly in the western part, evidences of late local glaciation occur. To the north and west glacial action of enormous extent and energy is noted. To the southwest in the Sierras, glacial action is also of great extent. Southerly glacial action is more scattered and "local," as are the irregular lava outbreaks extending through the adjoining states into Mexico.

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*Bulletin No 108, U. S. Geol. Survey.

To the east lies that remarkable and interesting feature, the "unglaciated area." In this area are the "bad lands" of Dakota, full of beds of Tertiary fossils in a perfect state of preservation. Glacier ice has never invaded this area, for not only are the most delicate fossils left untouched near the surface of the softest rocks, but every topographical feature is marked only by the denuding agency of water. The topography is marked and peculiar; whilst denuding agencies have been active at all times since the Tertiary—never has the grinding, moving glacier shaped the bluffs into rounded hills nor filled the valleys with gravels, sands and clays. On all sides except the western lava border, the mighty tread of the glacier has ground down and buried every pre-glacial feature. The great chain of moraines, erratic blocks, kames and kettle holes which traverse the continent skirts its northern border, but before turning south, retreats easterly for 8°, and then practically follows the course of the Missouri river southeast to latitude 37°, near the mouth of the Ohio; there it turns to the northeast and crosses the rest of the continent to cape Cod in 42° north. Within the limits of the area thus enclosed on the north and east by evidences of vast glacial action, and on the west by the great lava plain the gentler forces of water and air have alone shaped the topography; and within its borders are found abundant stores of fossil Tertiary life. These forms afford the links between the life of earlier and that of succeeding ages.

Although snow now covers the whole area in winter never did it accumulate so as to mould the rounded hills and slopes which are so characteristic of glaciated countries; and although the winter temperatures fall far below zero Fahr. the summers are warm and frequently characterized by intensely hot periods.

Whilst glacial denudation and markings are thus wanting there is no evidence to show that since the Tertiary, the streams have ever ceased to carve their vertical walls and to fill the valleys below with water borne sediments.

That this area should have escaped glaciation by reason of less elevation is not tenable for more southerly areas towards which both glacier ice and water flowed were deeply glaciated. That it should have escaped glaciation by reason of less precipitation is again faulty, for the massive Laurentide glacier, although reaching to the mouth of the Ohio, was limited by the Missouri, which for many hundred miles flowed against its base, and but rarely yielded more than a few scores of miles to its mighty advance. On the north the great glacial dispersion from the belt of maximum precipitation flowed towards it, and forced its way around the eastern border of the unglaciated area to the mouth of the Ohio in Lat. 37° N., or 8° nearer to the equator than to the pole. We must therefore confront the problem of its escape in its broad, bold form. Why should warm rain have fallen on the unglaciated area, whilst snow accumulated to enormous depths all around it except on the lava beds to the west, and flowed towards this area from the north.

Assumptions of unequal rainfall, and unequal upheavals have been appealed to as causes for the escape of this area from glaciation.

Unequal rainfalls could only have affected the depth of glaciation, but could not cause an escape, and could in no way have checked the flow of the great continental or Laurentide glacier.

To have remained at a lower level whilst adjacent areas were sufficiently upheaved to cause glaciation would have accelerated rather than retarded glacial flow from the northeast; consequently, these hypotheses complicate rather than explain the phenomena.

The presence of the great chain of glacial material extending from the intersection of the 49th parallel and the 113th meridian, southeasterly to the intersection of the 38th parallel with the 89th meridian must be accounted for by showing that there were positive conditions causing the precipitation upon the unglaciated area to be rain instead of snow, and stopping or warding off the glacial flow from the north.

We have in the vast heat escaping from the Columbia lava plain, an energy starting before and continuing long after the Ice age had departed from this latitude.

The influence of this energy must have locally affected climatic conditions at all periods of intervening time, and these effects must be recorded in that area most exposed to their influence, namely, to the east, since this is the direction of atmospheric circulation.

The interpretation which the writer offers of these facts is simple. As the shrinkages of the crust took place, during the Tertiary and Quaternary, the weakest places in the land masses yielded, and the successive layers of lava composing the great lava plains were erupted and laid down at irregular locations and intervals. The final eruptions took place during the chill of the Ice age, and as the great loads of ice were laid down along the lines of maximum precipitation.

That these eruptions commenced in Tertiary time is indisputable; that they continued during subsequent time is manifested by finding side by side, and between successive layers of lava fossil forms akin to both Tertiary and modern types of life.*

The heat, the energy, liberated in the vast inundations forming the Columbia lava plains yet remains in noticeable quantity; its manifestations in the geysers of Yellowstone park profoundly impress the investigator and illustrate one of the ways deep seated heat escapes from a forming crust. The present phenomena could all be compassed in a square mile and are insignificant in energy when compared with the manifestations which for ages must have characterized the greater portion of the entire area now covered by lava measured by thousands of feet in thickness.

To no other cause can we attribute the checking of the great Laurentide glacier in its mighty invasion than to the warm air and rain which, continually passing over and falling upon the lava plains, made the Missouri a warm river during the Ice age, and made the unglaciated area the last resting place for Tertiary forms, and the undisturbed graveyard for their remains.

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*Bulletin No. 108, U. S. Geol. Survey, Appendix, p. 104.

THE DEVONIAN SYSTEM IN CANADA.*

By J. F. Whiteaves.

To the student of the early literature of the Palæozoic rocks, and especially to the palæontologist, the name of William Lonsdale will always be associated with the Devonian System.

Although the term Devonian was first definitely proposed by Sedgwick and Murchison in a paper read April, 1839, and published in the fifth volume of the second series of Transactions of the Geological Society of London, the authors of this paper are careful to state, (first) that "Mr. Lonsdale, after an extensive examination of the fossils of South Devon, had pronounced them, more than a year ago, to form a group intermediate between the Carboniferous and Silurian systems," and, (secondly) that "the previous conclusions of Mr. Lonsdale .... led the way to their proposed classification of the Cornish and Devonian formations."

Lonsdale, himself, in another paper printed in the same volume, distinctly claims that his suggestion, on the evidence of their fossils, that the South Devon limestones are "of an intermediate age between the Carboniferous and Silurian systems, and consequently of the age of the old red sandstone," was first made in December, 1837. S. P. Woodward, in the preface to the first part of his "Manual of the Mollusca," dated March, 1856, speaks of Lonsdale as his "friend and master, the founder of the Devonian system in geology."

Yet, so lately as in August, 1897, Mr. Marr is stated to have said† that "the Devonian system had been founded on stratigraphical grounds by Murchison and Sedgwick, and on palæontological grounds by Lonsdale and Etheridge." Surely it would have been more correct to have said that the existence of the Devonian as a distinct geological system was first indicated by Lonsdale in 1837 on purely palæontological evidence, and subsequently confirmed by Sedgwick and Murchison in 1839 on stratigraphical considerations.

However this may be, rocks of Devonian age have been discovered at various times in almost every province and district of the Dominion, and it is thought that a brief summary of the history of these discoveries and of the present state of our knowledge of the Devonian rocks of Canada, from a palæontologist's point of view, may be of interest on this occasion. In accordance with long usage in Canada, the line of demarcation between the Silurian and Devonian systems, in this address, will be drawn at the base of the Oriskany sandstone. It will also be convenient to consider the information that has so far been gained about the Devonian rocks of Canada in geographical order, from east to west, under the three following heads, viz.: (1) The Maritime Provinces and Quebec; (2) Ontario and Keewatin; and (3) Manitoba and the Northwest Territories.

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*Address of the vice-president and chairman of section E, Am. Assc. Adv. Sci., Columbus, Ohio, Aug. 21, 1899.

†Quarterly Journal of the Geological Society of London, vol. LIII, page 460.

1. The Maritime Provinces and Quebec.

Nova Scotia.

In a memoir accompanying a geological map of Nova Scotia, by Dr. Abraham Gesner, published in the Proceedings of the Geological Society of London for May 10, 1843,* the following paragraph occurs:

> "*Old red sandstone or Devonian Group.*—Above the Silurian beds there occurs, in several parts of the province, a bright red micaceous sandstone or conglomerate, accompanied by thin beds of red shale and marly clay, and in some places containing seams of fibrous gypsum. Hitherto, no organic remains have been found in it. At Advocate Harbour and on Moose river this sandstone is seen lying unconformably beneath the coal measures. At the latter locality the sandstone dips W. 21°, and the coal measures dip N. N. E. 60°. It is from a joint consideration of the mineral characters of this formation, and its relative position as compared with the coal measures, that the author has regarded it as the equivalent of the old red sandstone."

This would seem to be the earliest statement in regard to the occurrence of rocks of Devonian age in British North America, but Gesner then included in his old red sandstone group, certain outliers of Carboniferous limestone and possibly Trias, that are now known to be associated with rocks still held to be Devonian.

Not quite two years later than this, in a paper read before the Geological Society of London on January 22, 1845, Sir

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*Volume IV, part I, page 187.

William Dawson says that beyond cape John the newer coal formation "seems to overlie, unconformably, a series of hard grits, slates and limestones, with scales of Holoptychius, encrinites and fragments of bivalve shells, and which are probably of newer Silurian or Devonian age. The last-mentioned rocks, with various kinds of trap, form an elevated ridge belonging to the Cobequid chain of hills."*

Influenced, as he elsewhere tells us, by information supplied by Sir Charles Lyell, Gesner's earlier statements as to the Devonian rocks of Nova Scotia were modified in his "Industrial Resources of Nova Scotia," published at Halifax in 1849. In this volume the paragraph about the Devonian rocks is as follows:

> "Old red sandstone or Devonian group.—Above the Silurian strata there occur thick beds of conglomerate, bright red, and micaceous sandstones, red shale and marly clay. At Advocate Harbour, Parrsboro', Moose river, Horton, Shubenacadie, and other places, these rocks are seen dipping beneath the coal measures and gypsiferous red sandstones. The scales of fishes, and other organic remains, found in these deposits, are too scanty and imperfect to afford conclusive evidence of their relative age; but from a joint consideration of them, the mineral character of the formation and its position, it may be classed as the equivalent of the old red sandstone of Europe, or a part of the great Carboniferous series. The strata contain but few minerals of importance."

The first edition of the "Acadian Geology," by Sir William Dawson, published in 1855, contains a "Tabular View of Rock Formations in Nova Scotia," in which the Devonian is defined as including the "fossiliferous slates of Bear river, Nictaux, New Canaan, Pictou, Arisaig, etc., and perhaps also parts of the metamorphic rocks of the Cobequid and Pictou hills." In the fourteenth chapter of this volume the fossiliferous slates at Arisaig and the East river of Pictou are regarded as of Devonian age, on the authority of James Hall, but in a supplementary chapter, dated August, 1860, they are referred to the Silurian. Nine "fossils from the Devonian and upper Silurian (?) rocks of Nova Scotia" are figured in this volume, but none of these are specifically determined and only three are Devonian. But, in the supplementary chapter, four of the fossils of the Nictaux and one of the Bear River series are determined specifically. Of the former it is stated that Hall "compares them with the fauna of the Oriskany sandstone; and they seem to give indubitable testimony that the Nictaux iron ore is of Lower Devonian age." A fuller list of fossils from Bear river and Nictaux, in which sixteen species are described generically and nine specifically, was published in 1891.*

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*Quarterly Journal of the Geological Society of London, vol. I, page 235.

In the second and much enlarged edition of the "Acadian Geology," published in 1868, Sir William Dawson confirms and elaborates most of the statements about the Devonian of Nova Scotia in the first edition and "Supplementary Chapter," and figures a new Devonian Spirifer (S. nictavensis) from Nictaux.† He notes the occurrence of "obscure remains, evidently of land plants" in more or less altered rocks on the flanks of the Cobequids, etc., and more particularly the discovery, in 1866, of "stipes of ferns, apparently of two species, a Pinnularia, and branching stems much resembling those of Psilophyton, a characteristic Devonian genus," in a gray altered sandstone or quartzite underlying unconformably a Carboniferous conglomerate at Bear brook (now known as McCulloch brook) near the Middle river of Pictou.

Doctor Honeyman, in a paper read before the Nova Scotia Institute of Natural Science in November, 1870, and since published in its Transactions, describes, as of Devonian age, a red band of argillytes on McAra's and McAdams' brooks, near Arisaig, which he calls the "McAra's Brook strata," but in which he did not succeed in finding any fossils. Later collectors, however, have been more successful, and in 1885, Mr. T. C. Weston, of the Canadian geological survey, obtained from these argillytes "fragments of plants and fish teeth not certainly determinable, together with certain interesting" imprints "like those of Protichnites carbonarius."‡ From the same rocks, in 1897, Dr. Ami and Mr. Hugh Fletcher, of the same survey, collected fragments of Pterygotus, and of pteraspidian and other fishes. The fish remains obtained in these rocks in 1897 have been examined by Mr. A. Smith Woodward, of the British museum, who thinks that they are either uppermost Silurian or lowermost Devonian.

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*Acadian Geology, Supplementary Note to the Fourth Edition, pp. 20 and 21.

†Page 499, figs. 176, a, b.

‡Geological and Natural History Survey of Canada, Annual Report, new series, vol. II, page 68 P.

From 1872 to the present time Mr. Fletcher has been engaged in a minutely detailed examination of the geological structure of northern and eastern Nova Scotia, for the geological survey of Canada, which has published geological maps of the greater portion of this area on a scale of one mile to the inch. In 1887 he referred to the Devonian system the rocks below the Carboniferous conglomerate at loch Lomond, Richmond county, Cape Breton.* From that point he has since traced rocks that he has described as Devonian, on stratigraphical and lithological grounds, westward through the peninsula of Nova Scotia as far as the head of Cobequid bay and along both sides of Minas basin, where he has estimated that they attain a thickness of from 10,000 to 15,000 feet.† With some Silurian and the associated igneous rocks, he believes them to form the mass of the Cobequids.

Most of these rocks that Mr. Fletcher refers to the Devonian, had, however, previously been referred to other geological horizons. Among the more notable of these are the Horton series in Kings county, and the Riversdale series and Harrington river rocks in Colchester county. On purely palæontological evidence the Horton series had been referred to the Lower Carboniferous, and the Riversdale series to the Millstone grit, by Sir William Dawson, though it is now pretty generally conceded that both are unconformably overlaid by a marine Carboniferous limestone.

Owing to circumstances it has unfortunately happened that very little palæontological work has been done in Nova Scotia or on Nova Scotian material since 1873. With the view of stimulating the prosecution of researches in this direction, collections of fossils have been made, during the past four years and chiefly by Dr. H. M. Ami, of the geological survey of Canada, from many localities in the province, and some selected sets of these fossils have been forwarded to specialists.

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*Geological Survey of Canada, Report of Progress for 1877-78.

†See the Annual Reports of the same Survey for 1877-78, 1879-80-81, 1886 and 1890-91.

In the Christmas and New Year's week of 1897 and 1898, Mr. David White, of the United States geological survey, examined the fossil plants from Nova Scotia and New Brunswick in the Peter Redpath museum at Montreal, and in the museum of the geological survey at Ottawa. On the evidence of these plant remains Mr. White came to the following conclusions, which are summarized, by permission, from an unpublished report, in the form of a letter addressed to Dr. H. M. Ami, and dated January 12, 1898. (1). That the plant-bearing portion of the Horton series of Nova Scotia, as shown by Sir William Dawson in 1873, is nearly contemporaneous with the Pocono formation of the eastern United States, which has long been assigned to a basal position in the Carboniferous system. (2). That the Riversdale series of Nova Scotia (which Sir William Dawson referred to the Millstone grit) is of Carboniferous age and assuredly newer than the Horton series. (3). That the plant-bearing beds near St. John, New Brunswick, are not Middle Devonian, as had previously been supposed, but Carboniferous, and that they are the exact equivalents of the Riversdale series of Nova Scotia.

Early in January last, collections of fossil plants from the Horton and Riversdale series and Harrington river rocks, at several localities in Nova Scotia, were sent to Mr. R. Kidston, of Stirling, Scotland, an experienced palæobotanist, for examination and study. In a manuscript report upon these collections, addressed to the director of the Canadian survey, and received May 8, 1899, Mr. Kidston comes to almost exactly the same conclusions as those previously arrived at by Mr. White, and on perfectly independent grounds. In this report Mr. Kidston expresses the following opinions. 1. Of the Horton series he says: "These rocks appear to be undoubtedly Lower Carboniferous." "There is no evidence at all to support the opinion that they are of Devonian age." "All the evidence derived from a study of their fossils, points very strongly against this view." 2. Of the Riversdale series he says: "The two divisions of this series, the Riversdale Station and Harrington river rocks, may be treated together, as they contain the same fossils and are evidently of the same age." The whole of the fossil plants from the Riversdale series have a most pronounced Upper Carboniferous facies and markedly possess the characteristics of a Coal Measure flora. "Judged from a European comparison, no other conclusion can be arrived at." 3. Lastly, he says that "the question of the age of the Riversdale series is inseparably connected with the question of the age of the plant beds of St. John, New Brunswick." "The species contained in the Riversdale series are also met with in the St. John plant beds, where, however, a greater number of species has been discovered." "I do not," he adds, "wish to express my views as to the age of the St. John plant beds too strongly, but from what I have been able to learn from a study of the literature of the subject and an examination of specimens from these beds, it appears to me that they possess a flora of a much higher horizon than that assigned to them, and that in reality they are most probably Upper Carboniferous." "It must, however, be remembered that since Sir William Dawson wrote his work on the Pre-Carboniferous flora, very much has been done in Europe to work out the zones of the Coal Measure flora, and careful and accurate figures have been published which did not exist at the time he was carrying out his investigations." "A thorough revision of the work, especially in the light of subsequent collections and possible discovery of more perfectly preserved specimens seems most desirable, and also that a better series of figures be published."

As complete a collection as possible of the fish remains of the Horton and Riversdale series of Nova Scotia was sent to Mr. A. Smith Woodward in January, 1899, for examination and study, but no report upon these specimens has yet been received.

The Devono-Carboniferous problem in Nova Scotia and New Brunswick is far too complicated a question to be discussed at any length in an address of this kind. At present, however, it is obvious that there is some discrepancy between the views of the two geologists on the Canadian survey staff who have studied the question from a stratigraphical and lithological point of view, and those of the palæontologists whose names have been cited in this connection, as to the age of the Horton and Riversdale series of Nova Scotia, and of the plant-bearing beds near St. John, New Brunswick.

New Brunswick.

It would appear that Devonian rocks, or at any rate, rocks that have for many years been regarded as of Devonian age, were not recognized in New Brunswick until 1861. For, although Dr. Gesner made extensive geological explorations in the province last named, from 1838 to 1843, the strata that he refers to the old red sandstone, in his first report on a Geological Survey thereof, published in 1839, and in a short paragraph in chapter eleven of his volume on New Brunswick, published in 1847, are now regarded as of Carboniferous age.

The occurrence of fossil plants in rocks near St. John, was noticed by Dr. Gesner as early as in his second report on the Geology of New Brunswick, published in 1840, and Sir William Dawson states that a well-characterized specimen from these rocks, which he subsequently identified with the Calamites transitionis of Goeppert, was shown to him by the late professor Robb in 1857.*

In 1860 a small collection of fossil plants from the shales at the foot of the city of St. John, near the barracks, recently made by Dr. G. F. Matthew, was submitted to Sir William Dawson for examination. On the evidence of their fossil plants these rocks at St. John were referred to the Devonian system by Sir William, in a paper "on the Pre-Carboniferous flora of New Brunswick, Maine, and Eastern Canada," published in the "Canadian Naturalist and Geologist" for June, 1861. Seven species are recognized in this collection, six of which are described as new. Professor L. W. Bailey in his report on the geology of southern New Brunswick, says that "the same author, in June, 1861, after an examination of certain fossils in eastern Maine, asserted the Devonian age of the rocks containing them, and also of the sandstones constituting the peninsula of St. Andrews, which they closely resemble."

Immediately after this, rocks containing similar fossils and presumably therefore of Devonian age, were recognized at other localities in the neighborhood of St. John, or in St. John county, as at the Little and Mispec rivers, and more particularly at the Fern Ledges, in Lancaster parish. From the latter locality extensive collections of fossils were made by Dr.

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*Acadian Geology, Second Edition, page 502.

Matthew, professor Hartt and other local collectors in 1861, 1862 and 1863, and more recently by Mr. W. J. Wilson and Dr. Matthew. The luxuriant and singularly varied fossil flora of the Fern Ledges has been described by Sir William Dawson in 1862,[*] by professor Hartt in 1865,[†] by Sir William Dawson and professor Hartt in 1868,[‡] and by Sir William Dawson in 1871,[§] and 1882.[‖] The "revised list of the Pre-Carboniferous plants of N. E. America" in the first part of Sir William's memoir on "the fossil plants of the Devonian and Upper Silurian formations of Canada," published by the Dominion survey in 1871, contains the names of seven species of fossil plants from the Devonian of New Brunswick, nearly all of which are from the Fern Ledges. In the second part of the same memoir, published in 1882, two additional species were described.

The remarkable assemblage of air-breathing articulata and mullusca associated with these plant remains has been described by Salter in 1863,[¶] by Scudder in 1868,[**] by Sir William Dawson in 1880,[††] and by Dr. Matthew in 1888,[‡‡] and 1894.[§§] In the latter of these two papers Dr. Matthew states that the "air-breathing articulates of the plant-bearing bed of St. John so far recognized, consist of:

"Insects, nine species of eight genera	9
Myriapods, six species of several genera	6
Arachnid similar to Anthracomartus	1
Probable pedipalp. (Eurypteralla)	1
Probable Arachnid or Isopod (Amphipeltis)	1
Scorpion (Palæophonus arctus)	1

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[*] Quarterly Journal of the Geological Society of London, vol. XVIII, pp. 296-330.

[†] In an Appendix to Prof. Bailey's Report on the Geology of Southern New Brunswick.

[‡] Acadian Geology, Second Edition, pp. 534-556.

[§] Geological Survey of Canada. Fossil Plants of the Devonian and Upper Silurian formations of Canada.

[‖] Ibid., part 2.

[¶] Quarterly Journal of the Geological Society of London, vol. XIX, pp. 75-80.

[**] Acadian Geology, Second Edition, pp. 523-526.

[††] American Journal of Science, vol. XX, p. 413.

[‡‡] Transactions of the Royal Society of Canada, vol. VI, sect. 4, pp. 57-62.

[§§] Ibid., vol XII, sect. 4, pp. 95-100.

"Two species of land snails have also been found, raising the number of air-breathing animals found in the plant-beds at St. John to twenty-one kinds."

Elsewhere in this paper Dr. Matthew says that "later discoveries lead the author to think that Eurypterus pulicaris, Salter, should be referred to the myriapods or to the insects," and in the foregoing list it is evidently included with the insects. To this list also should be added a trilobite and an annelid (Spirorbis erianus, Dawson), which indicate marine or at least brackish water conditions, while from the description and figures it is difficult to see in what respects the very imperfect specimen described as a land shell under the name Strophites (since changed to Strophella) grandœva, differs from the presumably marine genus Macrocheilus.

Detailed descriptions of the stratigraphical relations of the presumed Devonian rocks near St. John, by Dr. Matthew, were published in 1863* and 1865,† and many additional facts in relation thereto are contained in professor Bailey's report on the Geology of Southern New Brunswick published in 1865. In 1863 Dr. Matthew gave the local and provisional names of the Mispec, Little River and Bloomsbury groups to the subdivisions of the supposed Devonian system in St. John county, the Little River group including both the Cordaites shales at the Fern Ledges, with their numerous fossil plants, insects, etc., and the Dadoxylon sandstone. The Little River group was at first supposed to be of Upper Devonian age, but in consequence of the investigations of professor Bailey and Dr. Matthew in 1870, Sir William Dawson, in 1871, expressed the opinion that the Mispec group represents the Upper Devonian, the Little River group the Middle Devonian, and the Lower Conglomerates (presumably the Bloomsbury group) the Lower Devonian. Matthew, in 1888, after stating that there is one unconformity between the Perry sandstone and the Mispec beds, and another between the Mispec beds and the Cordaite shales, thus re-divides the Devonian rocks of St. John county, the unconformities being marked by a dividing line.

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*Canadian Naturalist and Geologist, vol. VIII, pp. 241-259.

†Quarterly Journal of the Geological Society of London, vol. XXI, pp. 429-30.

"Perry Sandstones, with Upper Devonian flora according to Sir J. W. Dawson, but lithologically resembling the Lower Carboniferous sandstone.

"Mispec conglomerate and slate.

"Cordaite shales and flags, Middle Devonian flora. Insect remains (in oldest beds of the Cordaite shales).

"Dadoxylon sandstone (with an older Devonian flora, G. F. M.).

"Bloomsbury conglomerate, etc."*

On behalf of the Canadian survey, in 1870, professor Bailey and Dr. Matthew traced beds corresponding to the plant-bearing beds near St. John as far to the westward as Lepreau harbour in Charlotte county, where many fossil plants like those at the Fern Ledges were collected. Ten years later the distribution of the Devonian rocks in the southern part of the province, as far as then known, was thus summarized by Messrs. Bailey, Matthew and Ells.

"The areas of Devonian occurring in southern New Brunswick may be stated as follows:

"1. A large basin, or double synclinal, east of St. John harbour, occupying the valley of the Mispec, with a southern area extending northeasterly across the Black river, near the forks of the East Branch.

"2. Isolated outcrops on Coal creek and on Canaan river and North fork, presumably of this age, but lacking evidence of fossils.

"3. Small areas about St. John and Carlton, with possibly Partridge island.

"4. A small area about the eastern extremity of Spruce lake, on the St. Andrews railroad.

"5. A belt stretching west from Musquash harbour to Lepreau harbour, in which is contained the so-called anthracite mine of Belas basin, with a small detached area along the shore from By Chance harbour to Dipper harbour.

"A large area in the northern part of Charlotte county, embracing the former pale argillyte series and extending into Queens county."†

Prior to 1894 the Devonian age of these rocks had never been called in question. But, in a foot-note to page 79 of Sir William Dawson's "Synopsis of the Air-Breathing Animals of the Palæozoic Period in Canada up to 1894," published in the

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*Transactions of the Royal Society of Canada, vol. VI, sect. 4, p. 61.

†Geological Survey of Canada, Report of Progress for 1878-79, page 11 D.

Transactions of the Royal Society of Canada for that year, Dr. Matthew says of the Little River group (which includes the plant-bearing beds near St. John) that he has "recently found some reason to suspect that these beds are as old as Silurian." And, as already stated in connection with this phase of the Devono-Carboniferous problem in Nova Scotia, both Mr. White and Mr. Kidston, on the evidence of their plant remains, have independently and quite recently expressed the opinion that the plant-bearing beds near St. John are the exact equivalents of the Riversdale series of the Nova Scotia Carboniferous.

In northern New Brunswick an area of gray shale (with Psilophyton) and conglomerates, which are regarded as of Devonian age, on the east side of the St. John river, near the mouth of the Beccaguimic, is indicated in a map accompanying Dr. Ells' "Report on the Iron Ore Deposits of Carleton County," in the "Report of Progress of the Geological Survey of Canada for 1874-75." Dr. Ells, also, in the "Report of Progress" of the same survey for 1879-80, says that areas of Devonian rock are "seen at intervals along the lower Restigouche river," and that they "form a synclinal basin extending from near the town of Dalhousie westward to a point about two miles above Campbellton and terminating on the south side of the river at Old Mission point." This report is descriptive of explorations made in 1879, and in it the Devonian age of the rocks at Campbellton is assumed exclusively on the evidence of a few fossil plants (i. e., two species of Psilophyton, one of Lycopodites and one of Cordaites) that had been identified or described by Sir William Dawson. The remarkable fish-fauna at Campbellton was not discovered until June 27, 1881, but it will be more convenient to consider it later on, in connection with the equally notable fish-fauna discovered in 1879, on the opposite side of the lower Restigouche river at Scaumenac bay in the province of Quebec, as the two localities are only about sixteen miles apart. Another area of Devonian rocks in the northern part of the province is that on the Upsalquitch river discovered by Dr. Ells in 1879 and described also in the 1879-80 report.

Quebec.

The geological survey of Canada was instituted in August, 1842, but prior to the confederation of the provinces in 1867, the scope of its operations extended only over Upper and Lower Canada, now known as the provinces of Ontario and Quebec.

With the view of ascertaining whether the coal measures of New Brunswick did or did not extend into Canada, its first director, Sir W. E. Logan, devoted the summer seasons of 1843 and 1844 to a geological examination of the Gaspé peninsula and of the country between it and the Baie des Chaleurs. In 1843 he surveyed the coast from Cap Rosier to Paspebiac, and in 1844 the exposures between Cap Rosier and Cap Chatte, thence following the Chatte river to the Cascapedia and crossing to the Baie des Chaleurs. During these two years the main geological features of the part of the province examined were, for the first time, definitely ascertained, and the absence of any productive coal measures north of the Baie des Chaleurs demonstrated. In 1843 the sandstones and limestones of Gaspé bay, since known as the Gaspé sandstones and limestones, were carefully studied and their fossils collected. In 1844 the Gaspé sandstones were traced for a considerable distance up the St. Lawrence, and in the "Report of Progress" of the survey for 1847-48 they are said to extend from the very extremity of the Gaspé district to Matapedia lake, a distance of 150 miles, and their thickness is estimated at 7,000 feet.

As early as 1845, if not in 1844, the Devonian age of the Gaspé sandstones was recognized by Logan. In the annual report of the survey under his direction for 1844 (which, though written in 1845, was not published until 1846), these sandstones are said to "resemble the Chemung and Portage groups of the state of New York, with perhaps the addition of what the geologists of that state term their Old Red sandstone" (i. e. the Catskill group), and to be overlaid by the Carboniferous series. At that time the Gaspé sandstones were regarded as of Upper Devonian age, but the numerous fossils that Logan had collected from them had not then been critically studied by any competent palæontologist. In an entry in his notebook for August 20, 1843, published in the "Life of Logan" by Dr. Harrington, it is distinctly stated that the plants of these sandstones are "not Carboniferous." A few years later, in a communication to the meeting of the "British Association for the Advancement of Science" at Ipswich, in 1851, Logan thus expresses himself: "None of the productive part of the New Brunswick coal measures reaches Canada, but there comes out from beneath it, on the Canadian side of the Bay Chaleurs, 3,000 feet of Carboniferous red sandstones and conglomerates. These are succeeded by 7,000 feet of Devonian sandstones, which rest upon 2,000 feet of Silurian rocks consisting of limestones and slates."*

Six of the species of fossil plants collected from the Gaspé sandstones by Logan in 1843 were described by Sir William Dawson: four (Psilophyton princeps, P. robustius, Lepidodendron gaspianum and Prototaxites logani) in the Quarterly Journal of the Geological Society of London for January, 1859,† and two (Cordaites angustifolia and Selaginites formosus) in the "Canadian Naturalist and Geologist" for June, 1861. In the former of these papers the two remarkable genera Psilophyton and Prototaxites were first proposed and defined. Subsequently, however, in 1888, Sir William somewhat modified his earlier descriptions of Prototaxites, and changed its generic name to Nematophyton.‡ Selaginites formosus was abandoned "as a vegetable species" by its author, in 1871, because additional material showed that the specimens upon which it was based are "probably fragments of some eurypteroid crustacean,"§ as suggested by Mr. Salter.

The supposed worm-tracks from the Gaspé sandstone between Tar point and Douglastown, discovered by Logan in 1843, were described and refigured by the writer, under the name Gyrichnites gaspensis, in the Transactions of the Royal Society of Canada for 1882.

Logan's examinations of the Gaspé series of sandstones and limestones were supplemented by those of Murray on the

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*Report of the Twenty-first meeting, page 61.

†Volume XV, p. 477.

‡The Geological History of Plants, page 21; and Transactions of the Royal Society of Canada for 1888, sect. 4, pp 27-47.

§Geological Society of Canada. The Fossil Plants of the Devonian and Upper Silurian formations of Canada, part 1, page 65.

Douglastown and St. John rivers in 1845, of Richardson on the Magdalen river and upper part of the Dartmouth in 1857, and of Bell on the Dartmouth, York and Malbaie rivers in 1862. Sir William Dawson, also, made extensive collections of fossils around the shores of Gaspé bay in 1858 and 1869, and Dr. Ells a general geological survey of the Gaspé peninsula, from Gaspé basin to the Matapedia river and from the St. Lawrence river to the Baie des Chaleurs in 1880-83, and a similar survey of the Devonian basin of the Causupscal river in 1884.

The collections made by Sir William Dawson in 1869 added thirteen additional species of fossil plants to the flora of the Gaspé sandstones, and these species were described and illustrated in the first part of his memoir on the "Fossil Plants of the Devonian and Silurian Formations of Canada," published by the Canadian survey in 1871. The "Geology of Canada," published in 1863, contains lists of some of the marine invertebrate fossils of the Gaspé limestones and sandstones, collected by Logan, Dawson and Bell, and these fossils were more fully determined or described by E. Billings in the first part of the second volume of Palæozoic Fossils, published by the Canadian survey in 1874. A small species of Cephalaspis, also, collected by professor G. T. Kennedy, then one of Sir William Dawson's assistants, from the Gaspé sandstone on the north side of Gaspé bay, in 1869, was described and figured by professor Ray Lankester, in the Geological Magazine for September, 1870,* under the name C. dawsoni.

In the "Geology of Canada" it is stated that the "limestones of cape Gaspé appear for the most part to belong to the Lower Helderberg group. The fossils at the summit, however, bear a striking resemblance to those of the Oriskany formation, with which several of them are identical. It appears probable, therefore, that we have here a passage from the Lower Helderberg to the Oriskany, and the latter formation may be more especially represented by the lower part of the Gaspé sandstones." Eleven years later, in 1847 † E. Billings expressed the opinion that the lower 330 feet of the Gaspé limestones are Upper Silurian (Lower Helderberg), the middle 880 feet passage beds, and the upper 800 feet Devonian.

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*Volume VII, page 397.

†Geological Survey of Canada. Palæozoic Fossils, vol. II, part 1 page 1.

At the other end of the province a small area of rocks on the Famine river, in Beauce county, and another on the west side of lake Memphremagog, in the county of Brome, were recognized as Devonian by Logan in 1863.*

Quite recently, too, a re-examination by Mr. Schuchert, of some of the brachiopoda from the small masses of limestone on St. Helen's island, opposite Montreal, has shown that these limestones are probably the equivalent of part of the Hamilton formation of Ontario and New York, and not of the Lower Helderberg.

Although the Devonian system is pre-eminently the age of fishes, yet for many years scarcely any remains of fossil fishes had been found in the Devonian rocks of Canada, that are at all closely comparable with those of the old red sandstone of Scotland and Russia. As early as 1842, however, the rocks on both sides of the lower Restigouche river were examined by Dr. Gesner, who says that he found the "remains of fish and a small species of tortoise, with fossil foot-marks,"† in the shales and sandstones at Escuminac (now called Scaumenac) bay, which he supposed were of Carboniferous age. The statement in regard to the fossils at this locality attracted no particular attention at the time, but in September, 1879, Dr. Ells found a natural mould of the exterior of the ventral surface and one of the lateral appendages of a Pterichthys-like fish in a concretionary nodule at Scaumenac bay, and in June, 1881, remains of a species of Cephalaspis in the brecciated limestones near Campbellton. The first of these discoveries led to further investigations by officers of the Canadian survey in 1880, 1881 and 1882, which revealed the existence of a remarkable assemblage of fossil fishes and land plants of Upper Devonian age at Scaumenac bay, and of an entirely different series of fishes and plants, of Lower Devonian age, on the opposite or New Brunswick side of the river, near Campbellton. Large collections were made at each of these localities, especially of the fossil fishes, which were described by the writer in 1880,[*] 1881,[†] and 1883,[‡] and described and illustrated in 1887[§] and 1889.[||] Many of these specimens were exhibited and described at the meeting of this association at Montreal in 1882.

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*Geology of Canada, pages 428 and 436.

†Report on the Geological Survey of the Province of New Brunswick, etc., St. John, 1843, page 64.

In the collections from Scaumenac bay made up to 1882 and described by the writer, the Elasmobranchii are represented by two species of Acanthodes (A. concinnus and A. affinis); the Ostracodermi by numerous, remarkably well preserved and nearly perfect specimens of a Bothriolepis (B. canadensis) which Gesner seems to have thought was a small tortoise; the Dipnoi by a supposed Phaneropleuron (P. curtum), the type of Traquair's subsequently described genus Scaumenacia;[¶] and the Teleostomi by a Glyptolepis (G. quebecensis), a Cheirolepis and a new genus (Eusthenopteron) closely allied to Tristichopterus. A few of the superficial and presumably sensory grooves on the cranial shield of the Canadian Bothriolepis were mistaken for sutures, as the similar ones of the European species had been by Lahusen, but some of the specimens of that genus from Scaumenac bay threw quite a new light on the structure of its mouth organs, and of the so-called "lid" with its pineal element. And, similarly, a portion of one side of the head of a specimen of Eusthenopteron from the same locality, which by an oversight was referred to Phaneropleuron, has almost all the sclerotic plates of the eye preserved.

From the collections made near Campbellton in 1881 and 1882, four species of fossil fishes were described, viz., Cephalaspis campbelltonensis; a supposed Coccosteus (C. acadicus) the type of Traquair's subsequently characterized genus Phlyctœnaspis,[**] and two kinds of fin spines.

Numerous fossil fishes from both of these localities have since been collected by Mr. Jex for Mr. R. F. Damon, of Weymouth, England, and these have been acquired by the Edinburgh and British museums. These later collections have yielded some additional species, one from Scaumenac bay, which was described by Dr. Traquair in 1890; and six from near Campbellton, three of which were described by Dr. Traquair, one in 1890 and two in 1893, and three by Mr. A. Smith Woodward in 1892. The latest novelty from Scaumenac bay is a new Cephalaspis (C. laticeps Traquair), of which it is said that "this is the first occurrence of a cephalaspid in rocks of later age than the Lower Devonian."* The three additional species from Campbellton, that Dr. Traquair has described, are two ichthyodorulites (Gyracanthus incurvus † and Cheiracanthus costellatus)‡ and another Cephalaspis (C. jexi).§ The three from the same locality described by Mr. A. Smith Woodward, in the eighth volume of the Third Decade of the Geological Magazine, are all elasmobranchs, viz., Acanthodes semistriatus, Protodus jexi, and Diplodus problematicus, the latter being the type of Traquair's genus Doliodus,|| published in 1893.

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[*] American Journal of Science, vol. XX, page 132; and reprinted in the "Canadian Naturalist and Geologist", vol. X, page 23.

[†] American Journal of Science, vol. XXI, page 94; and reprinted in the Annals and Magazine of Natural History, fifth series, vol. VIII, page 159; and "Canadian Naturalist and Geologist", vol. X, new series p. 27, and p. 93.

[‡] American Naturalist, vol. XVII, p. 158.

[§] Transactions of the Royal Society of Canada, vol. IV, sect. 4, p. 101.

[||] Ibid, vol. VI. sect. 4, p. 77.

[¶] Geological Magazine, June 1893, Decade 3, vol. V, p. 262.

[**] Geological Magazine, Decade III, vol. VII, page 144.

In 1882 Sir William Dawson determined or described the fossil plants from Scaumenac bay, four specifically and four only generically, and identified six species of fossil plants from near Campbellton with the Psilophyton princeps, P. robustius, Arthrostigma gracile, Leptophlœum rhombicum, Cordaites angustifolia and Prototaxites logani of the Gaspé sandstones. He asserts that the plant and fish-bearing beds at Scaumenac bay are "no doubt the equivalents and continuation of the upper part of the Gaspé sandstones," and that the fossil plants from near Campbellton are "perfectly identical with the lower part"¶ of these sandstones.

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*Ibid., Decade III, vol. VII, page 16.

†Ibid., page 21.

‡Ibid., Decade III, vol. X, page 146.

§Ibid., page 147.

||Ibid., page 145.

¶Geological Survey of Canada. The Fossil Plants of the Erian (Devonian) and Upper Silurian formations of Canada. Part 2.

2. ONTARIO AND KEEWATIN (HUDSON BAY).

While Logan was exploring the Gaspé sandstones, in 1843, Mr. A. Murray, then assistant geologist to the Canadian survey, was engaged in a "geological examination of the district lying in a general line between Georgian bay, on lake Huron, and the lower extremity of lake Erie." In his report on that year's operations, published in 1845, Mr. Murray correctly, and for the first time, regards the rocks at Port Colborne, Cayuga, etc., which he calls the upper limestones, as the equivalents of the Corniferous limestone of the state of New York. The black bituminous shales at Kettle point, lake Huron, and on the Sydenham river, that he examined in 1848, he at first thought to be part of the Hamilton formation, but in 1855 he re-examined these shales and some of the exposures on the Sable river and in the township of Bosanquet, in company with James Hall, upon whose authority the former were decided to represent the lowest member of the Portage and Chemung group and the latter the Hamilton formation. But this statement was not published until 1857.

The discovery of the Oriskany sandstone at Cayuga would seem to have been made, or rather first recorded, by E. Billings in May, 1860. For, in the preface to his now classical paper "On the Devonian Fossils of Canada West," Mr. Billings says that the "Devonian rocks of Canada West consist of portions of the Oriskany sandstone, Schoharie grit, Onondaga limestone, Corniferous limestone, Hamilton, Portage and Chemung groups." This paper was originally published in four parts, and in the third and fourth parts, fourteen of the species of Brachiopoda therein enumerated or described are said to occur in the Oriskany. The "Geology of Canada," published in 1863, contains a list of thirty species of fossils from the Ontario Oriskany, most of which, in the museum of the geological survey at Ottawa, are labelled as having been collected by J. De Cew. In that publication it is stated that only the lowest of the three divisions of this formation extends into Ontario, that it occupies only a few small areas in the townships of Dunn, Oneida and Cayuga, as a "very narrow border" to the Corniferous, and that it "seldom exceeds about six feet in thickness." A "list of the fossils occurring in the Oriskany sandstone of Maryland, New York and Ontario," by Mr.

Schuchert, published in 1889, in the eighth annual report of the geologist of the state of New York, contains the names of seventy-six species from Cayuga. Most of the Ontario material from which this list was made was probably obtained from Mr. De Cew. But Mr. Schuchert, who made additional collections of the fossils of the Ontario Oriskany for the United States National museum in 1895, says, in a recent letter to the writer, that he then saw how easy it is to mix Oriskany and Corniferous fossils while collecting, and believes that the collections made by Mr. De Cew are mixed. Mr. Schuchert thinks that near Cayuga there is a transition zone between the Oriskany and true Corniferous, and that many of the fossils recorded in the "Geology of Canada" as from the Oriskany may be from this zone. Further, he is of the opinion that it is only the uppermost portion of the Oriskany that is represented near Cayuga.

The fossils of the Corniferous formation or Upper Helderberg group of Ontario have been determined or described, either separately or together with those of the Hamilton formation, by E. Billings and professor H. A. Nicholson, in Canadian publications ranging from 1857 to 1885. Incidentally they have been described or enumerated by James Hall in the thirty-fifth regent's report of the New York State cabinet of natural history, and in volumes four to eight of the palæontology of that state; also by Dr. Carl Rominger in his "Fossil Corals" of Michigan.

Tabulating the information obtainable from these and other sources, and omitting names that have long been known to be synonyms, the number of species of fossils that have been recorded from this formation in Ontario would seem to be 258, as follows:

Corals (inclusive of Stromatoporoids)	100
Vermes	1
Polyzoa (=Bryozoa)	40
Brachiopoda	60
Pelecypoda (=Lamellibranchiata)	10
Gasteropoda	17
Cephalopoda	8
Ostracoda	1
Trilobita	17
Fishes	4
	258

In addition to these, there are in the museum of the Canadian survey a few fragmentary crinoids, several species of Polyzoa, a few Brochiopoda, pelecypoda and Gasteropoda, and one pteropod, (an undetermined species of Tentaculites) from the Corniferous of Ontario, that have yet to be studied.

From this list it would appear that corals form by far the most conspicuous feature in the fauna of the Ontario Corniferous. But, although in places this formation is mainly a large coral reef, it is obvious that quite a number of the species that have been proposed therefrom are based upon very insufficient characters. For some time past the writer's friend and colleague, Mr. L. M. Lambe, has been engaged in a much-needed revision of the Canadian palæozoic corals, and when this revision is completed, as it is hoped it soon will be, it will doubtless materially reduce the number of species from the Corniferous of the province. On the other hand, the number of species of polyzoa, brachiopoda and mollusca from that formation, in collections that have yet to be studied, will be quite largely increased.

The fossils of the Hamilton formation of Ontario have been reported on by Billings, Nicholson, Hall, and more recently by the writer, who has published two small monographs upon them. In the latter of these, published in November, 1898, 219 species are recognized and recorded as follows:

Sponges	2
Corals (inclusive of Stromatoporoids)	40
Echinodermata	16
Vermes	14
Polyzoa (=Bryozoa)	40
Brachiopoda	61
Pelecypoda (=Lamellibranchiata)	13
Gasteropoda	12
Pteropoda	3
Cephalopoda	8
Ostracoda	3
Phyllopoda	1
Trilobita	4
Fishes	2
	219

Several additional species of Fenestellidæ and Monticuliporidæ are indicated, in the Canadian survey and other collections, by mere fragments that have not yet been critically examined. From a comparison between the foregoing lists it would appear that Echinodermata and Vermes are more numerous in genera and species in the Hamilton formation than in the Corniferous, but eight of the fourteen species of Vermes from the Hamilton formation are jaws or teeth of conodonts that are very small and difficult to find.

The black shales at Kettle point, which are supposed to represent the Genesee slates of the state of New York, have so far yielded only a still undetermined Lingula, and four species of fossil plants (Calamites inornatus, Lepidodendron primœvum, macrospores of Protosalvinia huronense, and a Spirophyton) that have been determined or described by Sir William Dawson.

The Tully limestone, the supposed representative of the Cuboides zone of the European Devonian, and the Naples beds, or Intumescens zone, of western New York, have not yet been recognized in Ontario.

One of the results of the explorations of Dr. R. Bell, in 1871, 1875, 1877 and 1886, on behalf of the geological survey of Canada, was the discovery of a large area of Devonian rocks to the west and southwest of James bay. In 1871 Dr. Bell collected a few fossils on the Albany river (which is now part of the dividing line between Ontario and the District of Keewatin) between Marten's falls and the Forks; and in 1886 a much larger number on the same river below the Forks. Some of these fossils are from a yellowish gray limestone, and those obtained from this limestone in 1886 represent seventeen species. Twelve of these appear to be identical with Corniferous species from Ontario and New York state, and the remainder are either undeterminable or undescribed. Others are from small patches of red marl, and these fossils seem to indicate the Hamilton formation, the prevalent species being perfect and well preserved specimens of Spirifera pennata (Atwater), formerly known as S. mucronata Conrad.

Collections of fossils, that are obviously of Devonian age, were made by Dr. Bell in 1875 and 1877 on the Moose river, and two of its larger tributaries, the Missinaibi and Mattagami. Lists of these fossils, most of which are identical with well-known Corniferous species, were published in the "Reports of Progress of the Geological Survey of Canada" for 1875-76 and 1877-78. For many years a number of fossils from the Devonian rocks of the Albany river at old Fort Henley and of the Moose river, collected by the late Mr. George Barnston about 1834 or 1835, have been in the museum of the Canadian survey, but nothing appears to have been published about them.

In Keewatin a few fossils, that are probably of Devonian age, were collected, in 1886, by Dr. R. Bell at two localities on the Attawapishkat river, and by Mr. Low from the Limestone rapids on the Fawn branch of the Severn river. These fossils have not yet been critically studied, but among those from the last-mentioned locality there is a recognizable fragment of Sphœrospongia tesselata, which is one of the most characteristic species of the Stringocephalus zone of the Manitoba Devonian. The existence of Devonian rocks on Southampton island has been quite recently inferred from the fact that a few fossils from that island, lent to Dr. Bell by a missionary in 1898, are similar to those from the Attawapishkat river. Dr. Bell had previously stated that the limestone on Southampton island is "evidently exactly the same as that of Mansfield island."* If this be the case, the limestone of Mansfield island may possibly be Devonian rather than Cambro-Silurian as previously supposed.

3. MANITOBA AND THE NORTHWEST TERRITORIES.

The Devonian age of the limestones on Snake island, lake Winnipegosis, and Manitoba island, in the lake of that name, was asserted by E. Billings, in 1859, on the evidence of a few fossils collected therefrom in 1858. At the time Mr. Billings was under the impression that these limestones are, as he says, "most probably about the age of the Hamilton group."† In 1874 Dr. J. W. Spencer collected some fossils, which Mr. Billings pronounced to be also of Devonian age, from rocks on the island and shore of Swan lake and on the western shore of Dawson bay, lake Winnipegosis. Still more recently, an almost exhaustive geological examination of the islands, shores and immediate vicinity of lakes Manitoba and Winnipegosis was made by Mr. J. B. Tyrrell in 1888 and 1889. Assisted by Mr. D. B. Dowling, Mr. Tyrrell also made an exceptionally large collection of the fossils of the Devonian rocks of this region. This collection, which has been reported on somewhat fully by the writer in two illustrated papers published in 1891* and 1891,† was found to consist of 133 species, but about nineteen of these could not then be determined specifically. Two additional species of corals in this collection have since been determined, and an additional species of Pteropoda from a collection made later has been described, making the total of identified or described species now known from these rocks to be 117, as follows:

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*Geological and Natural History Survey of Canada, Report of Progress of 1882-83-84, p. 34 D. D.

†Hind's Report on the Assiniboine and Saskatchewan Exploring Expedition, Toronto, p. 187.

Sponges (inclusive of Receptaculitidæ)	2
Corals (inclusive of Stromatoporoids)	17
Vermes	1
Polyzoa (= Bryozoa)	5
Brachiopoda	18
Pelecypoda	25
Gasteropoda	29
Pteropoda	2
Cephalopoda	9
Ostracoda	3
Trilobita	3
Fishes	3
	117

According to Mr. Tyrrell these fossils are exclusively from the Middle and Upper Devonian of the province, for the Lower Devonian has not yet been satisfactorily recognized in Manitoba, though it may be represented by about 100 feet of red and other shales, from which no fossils have yet been collected. In any case they are of special interest as showing certain well marked and not altogether unexpected points of resemblance to those of the English and European Devonian. For, the upper half of the Manitoba Middle Devonian, or Winnipegosan formation of Mr. Tyrrell, consists of a tough white dolomitic limestone holding numerous examples of a large Stringocephalus which is apparently identical with the S. burtini of Defrance and of other European authors. Moreover, it is here associated with many fine specimens of Sphœrospongia tesselata Phillips, and with fossils that cannot at present be distinguished from the following well-known European species.

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*Transactions of the Royal Society of Canada, vol. VIII, sect. 4, p. 93.

†Geological Survey of Canada, Contributions to Canadian Palæontology, vol. 1, pt. 4.

Cladopora cervicornis (De Blainville).
Spirorbis omphalodes Goldfuss.
Productella productoides (Murchison).
Stopheodonta interstrialis (Phillips).
Atrypa reticularis L.
Atrypa aspera Schlotheim.
Pugnax pugnus (Martin).
Paracylas antiqua (Goldfuss).
Murchisonia turbinata Schlotheim.
Euomphalus annulatus Phillips.
Loxonema priscum Munster.
Marcrochilina subcostata (Schlotheim).

The Stringocephalus limestone of Manitoba would seem to occupy much the same stratigraphical position as that of Devonshire, Rhenish Prussia and Belgium, and its fossils show that it is probably their homotaxial equivalent.

Immediately above the Stringocephalus zone in Manitoba there are beds which may possibly represent the Cuboides zone, although Rhynchonella, or, as it is now called, Hypothyris cuboides, has not yet been found in them. The prevalent fossils in these beds are Cyathophyllum dianthus and C. vermiculare, var. præcursor (teste Frech); Chonetes logani var. Aurora, Productella subaculeata, Orthis striatula, Stropheodonta arcuata; and Cyrtina hamiltonensis, which the Rev. G. F. Whidborne has recently asserted is the same as the European C. heteroclita.

Regarding the fossils of the Manitoba Devonian as a whole, it is to be noted that it is not the corals, nor the Polyzoa (or Bryozoa), nor the Brachiopoda that have as yet yielded the largest number of species (as they have in Ontario), but the Gasteropoda and Pelecypoda.

From the northern end of lake Winnipegosis the Devonian rocks extend into the immediately adjacent district of Saskatchewan.

It has long been known that the eastern ranges of the Rocky mountains in Alberta are mainly composed of Carboniferous or Devonian, or perhaps of Carboniferous and Devonian, limestones and shales. These rocks were examined in 1858 and 1859 by Sir James Hector, who writes as follows in regard to them.

> "These limestones are of dark and light blue colour, crystalline, compact or cherty, with fossils that are either of Carboniferous or Devonian age, the principal of which are *Spirifer*, *Orthis*, *Chonetes*, *Conularia*, *Lonsdalsa*, *Cyathophyllum*, *Lithostrotion*, *etc.*"...... "Along with them are softer beds of gritty, sandy shale, generally of a dull red or purple colour."*. . "In the second range we have the same limestones and shales repeated as in the first, but at the base I observed traces of a magnesian limestone of a buff colour, containing *Atrypa reticularis*, a true Devonian fossil."†. . "On the Kicking Horse river, in the third range, we have the mountains again formed of blue limestone, along with a compact blue schist with red bands, giving a curious striped aspect to the rocks."‡

"In reference to these remarks, Dr. G. M. Dawson, who made a geological examination of the South Kootanie pass and its vicinity, in 1874, adds the following comments:

> "Dr. Hector is not very clear as to the separation of the supposed Devonian and Carboniferous limestones, and they may indeed very probably belong to a single series." "Prof. Meek, in describing fossils from limestones occuring in the mountains south of the boundary line, which, from the general facies, he believed to be Carboniferous, mentions the fact that the forms, without exception, belong to genera which are common both to that formation and the Devonian, and of which a small number are represented in the Silurian."§

In 1881, 1883 and 1884 Dr. Dawson was engaged in an examination of the geological structure of parts of the Rocky mountains in Alberta between Lat. 49° and Lat. 51° 30′, the results of which were published in the "Annual Report of the Geological Survey of Canada" for 1885 (Vol. I, New Series). This report contains preliminary lists of a few supposed Devonian fossils, from the limestones on the summit of the North Kootanie pass, on Crow Nest lake, and from the lowest beds exposed at the west end of the cañon on the Cañon branch of the Elbow river.

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*Palliser's Explorations in British North America, 1863, p. 239.

†Quarterly Journal of the Geological Society of London, vol. XVII (1861), p. 443.

‡Palliser's Explorations in British America p. 239.

§"Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel," etc., 1875, p. 71.

Subsequently Mr. R. G. McConnell made a geological survey of the Rocky mountains between the Canadian Pacific railway and the North Saskatchewan in 1885, and a more detailed exploration than had yet been made, of the geology of those in the more immediate neighborhood of that railway, in 1886. He published, in the "Annual Report of the Geological Survey of Canada" for 1886, a geological section across the Rocky mountains in the vicinity of the Canadian Pacific railway, with a diagram showing the formations represented in the sections to the west of the Castle Mountain range, and another of those represented in sections to the east of that range. In the latter, only four geological systems or formations are recognized, namely the Cambrian, which Mr. McConnell calls also the "Castle Mountain Group;" the Devonian, which he designates also as the "Intermediate limestone;" the Devono-Carboniferous, which he calls the "Banff limestone;" and the Cretaceous. In the text it is stated that the Intermediate limestone is "mainly composed of a great series of brownish dolomitic limestones and has a thickness of about 1,500 feet." Its fossils are "usually badly preserved and consist mainly of almost structureless corals." The few that were collected, it may be added, have not yet been determined and indeed are scarcely determinable. According to Mr. McConnell, the Banff limestone is the "principal constituent of all the longitudinal ranges east of Castle mountain." It "has a total thickness of about 5,100 feet and is divisible into a lower and upper limestone and into lower and upper shales." Its fossils are better preserved than those of the Intermediate limestone, and fairly large and representative collections of the former were made.

These collections have not yet been at all exhaustively studied, but most of the species represented in them are apparently of Carboniferous age. Among those collected in 1886 are two or three small species of Productus; a large Syringothyris; a Pugnax closely allied to if not identical with P. rockymontana Marcou; a Hustedia like H. mormoni (Marcou); and two well-marked pygidia of Proetus peroccidens, Hall and Whitfield. The specimens from the black fissle shales of the Bow river, collected by Mr. McConnell in 1885, that were provisionally referred to the Devonian genus Clymenia on page 18 D of his report, do not show clear indications of either septa or siphuncle, and may, therefore, be casts of a discoidal gasteropod. On the other hand, in 1885 Mr. McConnell obtained a few specimens, that are unquestionably referable to Atrypa reticularis, from the Rocky mountains at the Pipestone Pass falls, and from the first range on the North Saskatchewan. It was from the mountains at the source of the North Saskatchewan that the specimens were collected by Sir James Hector which Salter referred to A. reticularis.

In 1898 Mr. J. McEvoy collected a few fossils at several localities in the first foot-hill of the Rocky mountains, in Alberta, where it intersects the valley of the Athabasca. These fossils have not yet been very critically examined, but those from two of these localities are probably Carboniferous, and the remainder either Carboniferous or Devonian.

In 1868 Mr. F. B. Meek published a paper entitled "Remarks on the Geology of the Valley of Mackenzie River, with figures and descriptions of Fossils from that region, in the Museum of the Smithsonian Institution, chiefly collected by the late Robert Kennicott, Esq.," in the first volume of the Transactions of the Chicago Academy of Sciences. The paper consists of a concise history of the discovery of Devonian rocks at various localities in the Athabasca, Mackenzie river and Yukon districts, by Sir John Franklin, Sir John Richardson, Mr. A. K. Isbister, major R. Kennicott, Mr. R. W. McFarlane, Mr. B. R. Ross and the Rev. W. W. Kirby, followed by descriptions or identifications of thirty-two species of Devonian fossils Of these species ten are corals, twenty-one are brachiopoda and the remaining one is a cephalopod. Mr. Meek expresses the opinion that the Devonian rocks exposed on the Clearwater, Athabasca, Slave, and Mackenzie rivers, and on Great Slave lake, are probably referable to the Hamilton formation.

Since 1868 Devonian rocks have been discovered or examined by officers of the geological survey of Canada, and their fossils collected, at the following localities in this region. In the Athabasca district, at four different exposures on the Athabasca river and at one each on its tributaries, the Clearwater, Red and Pembina rivers, by professor Macoun in 1875, by A. S. Cochrane in 1881, by Dr. R. Bell in 1882 and by R. G. McConnell in 1890; also at three different exposures on the Peace river by professor Macoun in 1875 and by Mr. McConnell in 1879. In the Mackenzie district, on the banks of the Long Reach of the Lower Liard river and on the Hay river forty miles above its mouth by Mr. McConnell in 1887, and at four different and rather widely distant exposures on the Mackenzie river by Mr. McConnell in 1888.

Most of the fossils from these localities that were collected before 1875 have been provisionally reported on in the reports of progress of the Canadian survey for the years in which they were made. Those, however, that were collected between the years 1875 and 1890, both inclusive, form the subject of an illustrated paper, by the writer, on "The Fossils of the Devonian Rocks of the Mackenzie River Basin;" published in 1891.* This publication, which is practically a continuation of Mr. Meek's paper on the same subject, already referred to, adds fifty-seven additional species of purely marine Invertebrata to the previously known fauna of these rocks, as under:

Spongiæ	1
Corals (inclusive of Stromatoporoids)	10
Crinoidea	1
Vermes	3
Polyzoa (= Bryozoa)	7
Brachiopoda	20
Pelecypoda	7
Gasteropoda	3
Pteropoda	1
Ostracoda	3
Trilobita	1
Total	57

According to Mr. McConnell, a section of the Devonian rocks in the Mackenzie district, in descending order would be somewhat as follows:

1. Upper limestone (about)	300 feet
2. Greenish and bluish shales alternating with limestone (about)	500 feet
3. Grayish limestone, interstratified with dolomites, the lower part of which may be older than Devonian	2,000 feet (or more)

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*Geological Survey of Canada, Contributions to Canadian Palæontology, vol. I, part 3.

The whole of the fossils collected by Mr. McConnell, professor Macoun and Dr. Bell are from the upper part of the middle division of this section. Of the fifty-seven species of fossils in the foregoing list, twenty-two are apparently found also in the Hamilton formation of Ontario and the state of New York; ten (but only six additional ones) in the Devonian rocks of Iowa now referred to the Chemung; and seven in the Chemung of the states of New York and Pennsylvania. On the other hand, there are strong reasons for supposing that the whole of these fossils are from a horizon nearly corresponding to that of the "Cuboides zone" of Europe. In the first place, three specimens of a brachiopod which the writer has identified with the Rhynchonella (now called Hypothyris), cuboides of Sowerby, were collected by Mr. McConnell, one at the Hay river in 1887, and two on the Peace river at Vermilion falls in 1889. It is true that Mr. Schuchert thinks that these three specimens should be called Hypothyris emmonsi, but Mr. Walcott had previously expressed the opinion (in 1884) that "there is little doubt but that Rhynchonella intermedia, R. emmonsi and R. venustula Hall, are varieties of R. cuboides,* of the Devonian of Europe." On the Hay and Peace rivers the supposed Hypothyris cuboides is associated with Spirifera disjuncta (or Verneuili), and other fossils that are elsewhere supposed to be characteristic of the Cuboides zone are to be met with in the published lists of species from the Athabasca and its tributaries, or the Mackenzie. The discovery by Mr. McConnell at the Ramparts on the Mackenzie river, of two large specimens of a Stringocephalus which cannot at present be distinguished from S. burtini may indicate a northwestward extension of the Stringocephalus limestone of Manitoba. The still later recognition by Dr. John M. Clarke, in 1898, of Manticoceras intumescens in the cast of the interior of three chambers of the septate portion of a species of goniatite from the Hay river, collected by Mr. McConnell and figured by the writer, would seem to indicate the existence of the equivalent of the "Intumescens zone" or Naples fauna at that locality.

The present state of our knowledge of the Devonian rocks of the whole Dominion, from a purely palæontological standpoint, may be thus briefly summarized. We now possess a fairly satisfactory knowledge of the fossils of the Devonian rocks of Ontario, and of the relations which these rocks bear to the typical section in the state of New York. The fossil plants of the Gaspé sandstones have been described and figured by Sir William Dawson, and the remarkable assemblages of fossil fishes from the Upper Devonian of Scaumenac bay and Lower Devonian near Campbellton have been worked out somewhat exhaustively, the earlier collections in Canada, and the later ones by the best ichthyological authorities in London and Edinburgh. We have now some idea of the fossil fauna of the Manitoba Devonian, and have added materially to our knowledge of the fossils of the Devonian rocks of the Athabasca and Mackenzie River districts. But, on the other hand, our knowledge of the organic remains of the Devonian of Nova Scotia is still in its infancy, and it would seem that the plant-bearing beds near St. John, N. B., which have so long been regarded as Devonian, may possibly be Carboniferous. In the Rocky Mountain region of Alberta we have not always succeeded in distinguishing Devonian rocks from Carboniferous, and we have yet to obtain a much fuller knowledge than we now possess of the Devonian fossils of Keewatin and the area to the southwest of James bay.

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*Monographs of the United States Geological Survey, vol. VIII, (Palæontology of the Eureka District), page 157.

Ottawa, June 28, 1899.

THE GOLD-BEARING FORMATION OF STEPHENSON COUNTY, ILLINOIS.

By Oscar H. Hershey, Freeport, Ill.

Within the past several years, there have been occasional reports of the discovery of gold-bearing quartz in the solid-rock formations of a certain district in the western part of Stephenson county, in northwestern Illinois. I was long sceptical of the reality of these supposed finds, but recently the stories have been told in such detail, and have created local excitements of such a nature as to induce me, out of mere curiosity, to make a partial investigation of the matter. The result has been that I am now satisfied that gold in appreciable, (but not economical) quantities does exist in one or more strata of the Utica shale formation of this county. From the somewhat singular mode of its occurrence, and the isolation of this deposit far distant from the recognized goldbelts of the United States, it may be of more than local interest; and on this account I have ventured to present the following brief discussion of it.

The principal of the so-called "gold mines" is situated on the slope of the northern end of the "Erin mound," on the farm of Mr. Rudolph Staderman, just west of the village of Eleroy. The shaft is at present nearly full of water, but the proprietor, a very intelligent, prosperous and apparently veracious German farmer, gave me the following very detailed section of the strata penetrated:

1.	Black soil	2 feet.
2.	Yellow sandy loam, with stones	3 "
3.	Light bluish "hardpan" clay	5 "
4.	"Imitation" soapstone (bluish Cincinnati shales)	5 "
5.	Yellowish sandy clay, soft or loose, containing many disseminated nuggets of iron pyrites	1 foot.
6.	Layer of pyrite of iron	1 inch.
7.	Coal-black, laminated shale	3 feet.
8.	Layer of galenite, iron pyrites and native copper	1 inch.
9.	Very hard, light brown, sub-crystalline argillaceous limestone	6 inch.
10.	Dark, bluish-brown, clay-shales, soft	6 feet.
1.	Layer of iron pyrites	2 inch.
12.	"Cincinnati" clay-shales (Utica)	5 feet.
13.	Galenite, blende, and pyrites	1 inch.
14.	Layer containing copper	1 "
15.	Light gray limestone	3 feet.
16.	Layer of "black-jack" (blende)	1 inch.
17.	"Galena" limestone, full of nuggets of galenite	3 feet.
	Total	37 feet, 1 inch

No. 9 is the layer which carries the gold. It dips 45 toward the west and increases in thickness from six inches to ten inches in four feet, and to nearly three feet in ten feet. These features give it somewhat the appearance of a true fissure vein which it is not. The shaft was sunk on a crevice about one-eighth inch wide, nearly vertical and striking N. N. E. to S. S. W. It contains oxidized pyrites or oxide of iron above No. 9, and much iron pyrites and other minerals below that stratum. Yet it has had nothing to do with the presence of the metallic sulphides which so highly impregnate the lower strata cut by the shaft. The limestone layer, No. 9, is one of the regular strata of the brown shale series, and the "gold ore" may be said to occur in the form of a "blanket vein" rather than of a vertical or fissure vein. The layer of country-rock contains irregularly disseminated masses of rose quartz of the size of a walnut up to that of an apple or larger, and it is these quartz-filled cavities which carry the gold. An assay made from a piece of one of these quartz masses, on Nov. 4, 1897, by E. E. Burlingame & Co. of Denver, Colo., was returned as: Gold oz. per ton, 4.04 oz. valued at $80.80, (being at rate of $20.00 per oz. of gold); and a trace of silver. I see no particular reasons for discrediting the above returns as, from acquaintance with the parties interested, I do not believe any effort has been made to "salt" a mine. I have myself seen in the material from the mine, iron pyrites, zinc blende, galenite, native copper, quartz, calc spar, and free gold or the best imitation of it that I have ever encountered.

From the material thrown out of the shaft, and from outcrops farther down the hill-side, I recognize the first two strata of the above section as "drift;" Nos. 3 to 5, Cincinnati or Hudson River shales; Nos. 6 to 14 inclusive, Utica shales; and the remainder. "Everts limestone," a local designation of the upper portion of the Galena series. The black shale, No. 7, is very characteristic of the Utica in this northwestern portion of Illinois. Under it is a curious combination or alternation of thin layers of fine conglomerate or coarse sandstone, impure limestone, brown clay and layers of pyrites. I have long thought I detected evidence of an old soil layer or land surface at this horizon. However, the few feet of strata which make up this peculiar portion of the Utica series are always highly mineralized; indeed, in the gutters below the Eleroy "gold-mine," there are outcropping thin layers of coarse sandstone in which the cementing material is pure iron pyrites.

About a mile and a half west of Pearl City, and six miles southwest of the Eleroy mine, there is another of the so-called "gold mines" of this county. The several shafts here dug penetrate the same series of strata as at Eleroy, and the basal portion of the Utica shales and upper portion of the Everts limestone are almost equally as highly mineralized as at the other locality. In this case, I could secure no assay certificates, but it is a well-known fact that several assayers made returns of gold and silver contents of the ores submitted to them.

Between the two "mines" mentioned, the Utica shales, with the overlying Hudson River blue clays, etc., underlie an extensive tract several miles in average width, part of it forming the prominent elevation, "Erin mound." The supposed gold-bearing series is exposed in various ravines and gutters along the borders of the tract, and is cut through by Yellow creek. Everywhere are the peculiar, thin conglomerate layers and the high content of iron pyrites. These outcrops will doubtlessly continue to give rise to local gold excitements for many years to come; for I am of the impression that that particular portion of the Utica series contains a small amount of gold, along with the iron pyrites, throughout the district.

The facts which I wish to emphasize are that the gold and other minerals impregnate one or more strata of a certain series, and have no connection with fissure veins, but have been deposited in the strata by the simple process of segregation under the action of percolating (probably heated) waters. The gold must have originally existed, in a finely divided and widely disseminated state, in or close to the particular strata in which it is now found, and it was afterward concentrated and redeposited in the same or a very near portion of the strata. There is no reason to believe that these mineral solutions descended through the compact beds of blue Hudson River clays above, or came up through the St. Peter sandstone and Galena limestone. On the contrary, we may rather suppose that they traversed the strata laterally, depositing mainly galenite and blende in the limestone formation because lead and zinc minerals were originally disseminated through it, and depositing mainly iron pyrites and gold in the basal portion of the Utica formation because these strata had originally been supplied with those minerals rather than with lead or zinc.

In explanation of the large amount of iron pyrites in the basal portion of the Utica shales, and its rarity in all the other formations of northwestern Illinois, I have adopted an old theory which has often been urged in similar cases. I notice that the Utica shales of Stephenson county yield traces of sea-weed impressions, and the whole formation appears to be largely made up of vegetable debris. Some layers, also, are thickly packed with the remains of minute marine animals. The Utica formation in the Eleroy-Pearl City district seems to have been deposited in a shallow bay rather than under deep-sea conditions. This favored the growth of marine vegetation, and also its subsequent decay. Is it not possible, indeed more than probable, that the sulphurous gases resulting from this decaying vegetation and animal matter, forced and precipitated the iron (and possibly the gold) salts contained in the sea-water, so that these minerals came to make up an important original constituent of the Utica shales of this district?

It has been stated that in the Eleroy "mine" the gold is chiefly found in certain limited quartz-filled cavities in one particular stratum. Here the limestone has been dissolved out in spots and the spaces thus formed, simultaneously filled with quartz in which the gold, gathered throughout the stratum, was deposited in a concentrated condition. This was affected simply by water oozing through the pores of the rock, or, in other words, by segregation.

April 7, 1899, Freeport, Illinois.

A DISCUSSION ON THE USE OF THE TERMS ROCK-WEATHERING, SERPENTINIZATION, AND HYDROMETAMORPHISM.*

By George P. Merrill,
Head Curator, Dept. of Geology, U. S. National Museum, Washington, D. C.

In the abstract of a paper by Mr. Thomas H. Holland, read before the British Association, Section C (Geology), Bristol, 1898, printed in the January number of this Magazine,† on "The Comparative Actions of Subaërial and Submarine Agents in Rock Decomposition," the author brings up again a question which the present writer has often had occasion to face, and has vainly tried to solve in a manner entirely satisfactory even to himself.

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*Extracted from the Geological Magazine, Decade IV, Vol. VI, No. 422, p. 354, August, 1899.

†Geol. Mag., January, 1899, pp. 30-1.

The question relates primarily to the limitation of the term weathering as applied to rocks, and indirectly to the general subject of hydrometamorphism and metasomatosis as manifested in the production of serpentine.

In my work on "Rocks, Rock-weathering, and Soils" (p. 174), is made the following statement:—

"The term weathering, as here used, is applied only to those superficial changes in a rock-mass brought about through atmospheric agencies, and resulting in a more or less complete destruction of the rock as a geological body, as where granitic rocks are resolved into sand and kaolinic material, with liberation of carbonates of the alkalies and of lime, and oxides of iron. It does not include those deeper-seated changes taking place below the zone of oxidation and which result mainly in hydration and the production, it may be, of new mineral species, as chlorite, sericite, zeolites, etc., but during which the rock-mass as a whole retains its individuality and geological identity. The distinction is not one that has been sharply insisted upon, and, indeed, geologists and petrologists as a rule have been extremely careless in their use of such terms as alteration, decomposition, and weathering. The distinction drawn here is essentially that made by Roth (Allgemeine u. Chemische Geologie) between Verwitterung and Complicirte Verwitterung. For reasons above stated and others given on p. 161, it seems best to limit the terms weathering and decomposition to processes involving the destruction of the rock-mass as a geological body, and to designate the purely mineralogical, deeper-seated changes, as alteration, which may or may not be due wholly to hydrometamorphism."

This is essentially the ground taken by Lindgren also,* and while it may be open to criticism, nothing better, so far as the writer is aware, has been suggested.

Let us take for purposes of discussion the serpentinization of the mineral olivine, as mentioned in the abstract of Mr. Holland's paper. The author states (p. 31):—"In all these cases, however, although the action of the atmosphere is so striking, the results are purely superficial, and a specimen of rock taken from within a few inches of the clay products seldom shows a trace of hydrous decomposition, even in thin sections under the microscope. This is just as true for such delicate minerals as olivine and nepheline as for the commoner silicates. In many of the basic dykes, certainly pre-Cretaceous and probably Lower Palæozoic in age, the absence of serpentine is so complete that unusual precautions are often necessary for the determination of the olivine, whilst in the numerous occurrences of dunite throughout the Madras Presidency serpentine is extremely scarce."

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*17th Ann. Rep. U. S. G. S., 1895-6, pt. ii, pp. 90-6.

Mr. Holland would account for this wide difference in the conduct of the olivine in Indian and European localities on the supposition that the European areas had, during the later geological periods, been submerged below the sea, while in southern India there are no evidences of any such depression since Lower Palæozoic time.

Just what would be the effect of prolonged submergence in sea-water on a mass of olivine rock the writer is not prepared to say, but he does express the doubt if simple weathering of the mineral is ever productive of serpentine. Has there been ever advanced any proof that serpentinization is a superficial phenomenon? If due to weathering we ought somewhere to meet with masses which are superficially converted into serpentine and gradually resume their normal character at greater depths.

So far as is to be judged from available literature the olivine granules in any mass of rock, however dense, show no greater degree of hydration (serpentinization) near the surface or along contacts where surface waters would most readily permeate, than in the interior of the mass. Further than this, serpentinization is as common, so far as the United States is concerned, in the arid portions of the West as in the humid East. In fact, this phenomenon is apparently entirely independent of climatic conditions. Is not the inference, then, fair that the process has gone on entirely independent of surface waters?

Although convinced that excepting in the purely physical weathering of arid regions hydration is a most important factor,[*] the absence of any but a very narrow zone of hydration products between the residual clay and fresh rock is not at all strange. Much depends on the texture of the rock and its mineral composition. In cases where the weathering is largely in the nature of solution and oxidization such abrupt changes are to be expected. The Fourche Mt. syenite, of Arkansas, an almost purely feldspathic rock, passes within the space of 2 cm. from a fine red-brown unctious clay to a massive fresh unchanged feldspar: the nepheline of the nepheline syenite of Mias in the Urals is eaten out below the surface of the more refractory feldspar, mica, zircons, etc., but gives in the closed tubes only traces of water and shows under the microscope only incipient stages of hydration.

My own view of the case is, that the two phenomena are due to widely different causes; that serpentinization is a deep-seated process due to waters or vapours coming from considerable depths, and it may be even constituents of the magmas at the time of their intrusion. The almost complete absence of oxidization products in fresh serpentine is indicative of this. Again, serpentinization is a process involving a greater degree of hydration than is weathering. The serpentinized olivine rock of the Nijni Tagilsk platinum district yields 14.21 per cent. of water, while the brown crust which results from its weathering yields but 11.74 per cent. The serpentine of Harford county, Maryland, further, shows a loss on ignition of 18.15 per cent.,[†] while the hard red-brown crust produced on the immediate surface, through weathering, loses but 11.82 per cent., and the residual soil but 7.89 per cent. In the same manner soils derived by weathering from other highly hydrate magnesian rocks, as the so-called soap-stone (altered pyroxenites), show a very considerable loss of water, even though the actual loss on ignition in the resultant soil may be a trifle greater than in the fresh rock.

These facts are mentioned in detail here since they do not seem to have been before noted, or at least their significance not realized. If serpentinization were a product of weathering, a shorter exposure to atmospheric influences, as in India, ought to result in merely a thinner coating of serpentine over the altered material. Were it a result of subaërial agencies, certainly the superficial alteration of olivine into serpentine ought to be more nearly universal. Yet, in several instances, as notably in the corundum areas of western North Carolina, the olivine is almost perfectly fresh, but on the immediate surface rotted away to a ferruginous clay.

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[*] "Rocks and Rock-weathering," pp. 188, 234, etc.

[†] In part due to C O, though the amount of this constituent cannot be over 3 or 4 per cent.

That this process of hydration, hydrometamorphism, or alteration, whichever term may be used, is quite distinct from true weathering, is further shown by the corundum crystals of this same region. These are often superficially or quite altered to damourite. Yet both the corundum and the alteration products are so resistant to weathering that they remain among the residues in the clays resulting from the decomposition (weathering) of the mother rock, whatever that may have been. Serpentine pseudomorphs after pyroxene are sometimes more refractory than the rock in which they are formed, and may be found with well-preserved crystal outlines in the débris resulting from its breaking down.* When rocks like the Nijni Tagilsk peridotites, which are largely serpentinized but still contain residuary olivines, undergo actual weathering, the olivines do not yield serpentine, but break up, as does the serpentine itself into free iron oxides, free silica, carbonates of magnesia, and unrecognizable earthy products.

The ideas put forward in this paper are not altogether new, and are in part in harmony and in part in conflict with those advanced by others.

Thus Bischoff says:† "The decomposition of a rock takes place only when it is exposed to the undisturbed action of atmospheric agents; while alteration, on the contrary, takes place when the rock is more or less beyond the reach of this action." On the other hand, Roth,‡ to whom we owe so much, speaks of both serpentine and zeolites as products of weathering (Verwitterung), but in his latest work§ he so far changes his views or mode of expressing them as to call the deep-seated process Complicirte Verwitterung, in distinction from the purely superficial Verwitterung, due to atmospheric action. Moreover, in the paper "Ueber den Serpentin," to which reference is made above, he describes the processes and results incidental to the Verwitterung of the serpentine quite independently of those incidental to its first production.

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*J. Smith. "Crystals from Decomposed Trap": Geol. Mag., Dec. IV, Vol. VI (1899), p. 93.

†"Chemical and Physical Geology," Paul & Drummond's English translation, 1854, vol. iii, p. 86.

‡"Ueber den Serpentin, etc.": Abhandl. der K. Akademie der Wiss. zu Berlin, ii (1869), p. 42.

§"Allegemeine u. Chemische Geologie," 1893.

Teall*apparently accepts unhesitatingly ideas contrary to those expressed by myself, for he says: "The alteration of olivine by surface agencies—water, carbonic acid, and oxygen —gives rise to serpentinous and other pseudomorphs."

Consideration along these lines led the present writer in the work to which reference has been made to attempt making a distinction between true weathering and the more deep-seated process which he called hydrometamorphism. Surely processes so widely different as those resulting in the production of a serpentine from a peridotite and the final destruction through oxidation, carbonization, and partial dehydration of this same serpentine, should not be confounded under the same name. The distinction, it is true, is not one that can at all times be readily made. As the petrologist finds difficulty in separating his plutonic from the effusive rocks, so here are no hard and fast lines, and it is often impossible to state at just what point one shall assume that superficial processes cease and the deep-seated begin. The writer's conclusions are to the effect that the zone of oxidation forms the natural and easiest recognizable limit. The processes within this zone are those of weathering; those below, whether brought about by superficial waters deprived of their free oxygen and carbonic acid, or by deep-seated waters welling upwards, are those of hydrometamorphism, metasomatosis, alteration, or whatever suitable name may be adopted.

In conclusion, one might urge the necessity of closer observations regarding the formation of serpentine from olivine or other anhydrous magnesian silicates. That it is through a process of hydration is self-evident, but as to the conditions under which it goes on literature is strangely silent. Is the process still going on in the exposed masses now open to our inspection, or is it at a standstill? The writer is of the present

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*"British Petrography," p. 85.

opinion that both this process and that resulting in the formation of zeolites and chlorites have ceased, so far as material available for study is concerned. They are due to conditions which do not exist on the immediate surface, except it may be in such sporadic and unusual occurrences as those of Plombieres, or those more recently described by F. Gounard* and by Lacroix.† This paper is, however, written more for the purpose of eliciting the opinions of others than of expressing those of the writer.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Is the White River Tertiary an Æolian Formation? By W. D. MATTHEW. (Am. Naturalist, vol. XXXIII, No. 389, May, 1899.)

This article, which seems to have attracted less attention than it deserves, is an arraignment of the theory, heretofore almost universally held, of the lacustrine origin of the Tertiary deposits of the western plains in the United States.

The author of this pamphlet contends that the fauna ascribed to these Tertiaries is such as could not have been entombed in lake deposit as it is essentially a land fauna, almost entirely devoid of such mammals as lived in and around lakes; but that it is such a fauna as would have dwelt on dry plains. The opposite view is crystallized in all the textbooks, and if it is not founded in fact, the more widely has it been disseminated, the greater need of a revision to bring it more in accord with the facts.

Richthofen's description of the enormous loess deposit of the great river plains of northern China first challenged the attention of the scientific world to the possibility of great æolian deposits, and Matthews' observations appear to show that conditions similar to those of Tertiary times in China prevailed over a large area of the western United States at a similar period.

Matthews' objections to the lacustrine hypothesis are the following:

Stratigraphic: The vast extent of the postulated lake. The absence of any barrier to hold in its waters. The absence of beach lines or terraces. The absence of fine stratification in the clays.

Faunal: The absence of plant remains. The absence of aquatic invertebrates. The absence of fish and of aquatic reptiles; on the contrary land reptiles are the most common fossils. But the great point is the great number and variety of mammals that occur, and these almost entirely species of the land.

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*Bull. de la Société Minéralogique de France, vol. v (1882), p. 268.

†Comptes Rendus Paris Acad. Sci., vol. xxiii (1896), p. 761.

These are the main objections to the lacustrine hypothesis, but the more closely the fauna is examined the more numerous become the objections to a view that the skeletons were entombed in the bed of a great lake. For instance the bones of the mammals are scattered, gnawed and bitten, and those usually found are of parts of the body that are rejected by predatory animals. The author's conclusions are that "if the White River [Tertiary] clays are lacustrine they must have been deposited in an absolutely lifeless sea, surrounded by a well-watered region devoid of vegetation, yet sustaining an animal population or incredible density. And even this combination of improbabilities cannot account for some facts, and does not satisfactorily account for others."

The contrary hypothesis is sustained by the following conditions:

1. The fauna is such as we should expect to find in an open grassy region. The animals are all land forms, and the most abundant genera have distinctly cropping teeth. Laud tortoises are abundant.

2. The condition of the bones, gnawed and bitten, is similar to that of bones in the present prairie-deposit.

3. The character of the clays, without obvious stratification, or fine lamination is that which loess would assume on consolidation.

4. The great extent and uniformity of the deposit agrees with that of loess.

This theory of eolian origin of the White River Tertiaries does not apply to the Eocene bed west of the Rocky mountains, for the origin of which a lacustrine theory is reasonable.

Nineteenth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1897-98. CHARLES D. WALCOTT, Director. Part I: Director's Report, including Triangulation and Spirit Leveling. Part IV: Hydrography; F. H. NEWELL, Chief of Division. Part VI: Mineral Resources of the United States, 1897; DAVID T. DAY, Chief of Division. Washington, 1898-1899.

Three parts of this annual report, as here noted, making four volumes, have been recently distributed. They are published earlier than its second, third and fifth parts, which are to contain, respectively, papers chiefly of a theoretic nature, papers on economic geology, and reports of forest reserves.

The appropriations for the fiscal year here reported were in total $1,033,983.60. In the allotment of this sum, topographic work received $184,200; geologic work, $118,700; paleontologic work, $14,000; chemical work, $10,000; gaging streams and determining water supply, $50,000; the report on mineral resources, $20,000; engraving and printing maps, $60,000; preparation of illustrations of reports, $13,000; engraving illustrations, $17,000; printing and binding, $20,000; special appropriation for survey of forest reserves, $150,000; special appropriations for completion of surveys of the Indian Territory, $279,500; and for geologic and topographic surveys in Alaska, $20,000.

During this year the field work of the director consisted mainly in examinations of forest reserves in the Northwest, inspection of the Yellowstone and Yosemite national parks, and reconnaissance in eastern California. The director also makes brief statements of the scope of field work by thirty-three parties, five being employed in the New England region; four in the Appalachian region; three in the Atlantic coastal plain region; five in the interior or Mississippi region; six in the Rocky Mountain region; six in the Pacific region; two in Alaska; and two on the glacial drift.

Topographic surveys were made in thirty-five states and territories, the aggregate area surveyed being 35,867 square miles; and in connection with this work, 12,957 miles of leveling was done, with the establishment of 2,354 permanent bench marks. The total area surveyed up to the date of June 30, 1898, the end of the fiscal year, was 784,699 square miles, somewhat exceeding a quarter part of the national domain, exclusive of Alaska.

Outlines of the work done in examination and surveys of seven forest reserves, under the direction of Mr. Henry Gannett, are given here by the director; and a later volume of this report will present their results in detail.

Part IV, Hydrography, in 814 pages, with 118 plates, comprises papers by F. H. Newell and others, on progress of stream measurements in the year 1897; by Edward Orton, on the rock waters of Ohio; and a preliminary report, by N. H. Darton, on the geology and water resources of Nebraska west of the 103rd meridian. The first group of papers contains detailed reports of the water-power streams of Maine, other streams of the Atlantic coastal region, a few tributary to the Gulf of Mexico, several streams of the Ohio basin, the head waters of the Missouri, and the Yellowstone, Platte, Kansas, Arkansas, Colorado, Great Salt Lake, Columbia, San Francisco Bay, and San Bernardino basins. Much information on the topography and geology of all these regions is also given; and the papers by Dr. Orton and Mr. Darton are very important contributions to the geology of Ohio and western Nebraska.

Part VI, in two volumes, comprises reports on ores of iron and manganese, by John Birkinbine; on the American and foreign iron trade, by James M. Swank; on copper, lead, and zinc, by Charles Kirchhoff; on antimony, coal, coke, asphaltum, soapstone, abrasive materials, gypsum, salt, etc., by Edward W. Parker; platinum, by David T. Day; petroleum and natural gas, by F. H. Oliphant; stone, by William C. Day; clay statistics, by Jefferson Middleton; the kaolins and fire clays of Europe, by Heinrich Ries; precious stones, by George F. Kunz; mineral waters, by A. C. Peale; and two short reports on the mineral resources of Hawaii and of the Philippine islands, the latter by George T. Becker.

The total mineral products of the United States in 1897 amounted in value to $632,312,347, an advance beyond the preceding year by about $8,500,000. Almost all the important metallic products showed an increase; but the non-metallic decreased about $6,000,000, chiefly in petroleum and anthracite coal, although bituminous coal, natural gas, stone, cement, and salt, like the metals, increased in the values of their production. W. U.

Geological Survey of New Jersey, Annual Report for the Year 1898. JOHN C. SMOCK, State Geologist. Pages xxxii, vi, 244, and 102; with 28 plates, and 20 figures in the text.

Professor Smock, in his administrative report, announces that a map of the surface deposits of this state is being prepared on the scale of a mile to an inch, making thirty-four map sheets, to be accompanied by two volumes of descriptive text. This part of the state survey is under the direction of Prof. R. D. Salisbury, with Mr. G. N. Knapp as his assistant.

A new topographic map is also begun on the scale of 2,000 feet to an inch. The field work for the Newark, Jersey City, Paterson, Hackensack and Camden sheets has been done; and they are being engraved by Julius Bien & Co.

Much attention is being given to plans of dikes and canals for reclaiming the marshes which occupy about 27,000 acres between Elizabeth and Hackensack.

Forest surveys have been made by Mr. Gifford Pinchot and Prof. Arthur Hollick; a thorough investigation of the underground water supply is being made by Mr. C. C. Vermeule; and the fire-brick, other clay-working and iron-mining industries are reported by Mr. George E. Jenkins.

In the present annual report, Prof. Salisbury writes on "The Soils of New Jersey and their Relation to the Geological Formations which underlie them"; and this paper includes a small preliminary map of the surface formations of the state. Dr. Henry B. Kümmel reports on the northward extension of the Newark system of rocks in New York, to their end on the Hudson river at Stony Point. Mr. Lewis Woolman continues his very valuable records of artesian wells; Mr. Vermeule treats of water supply from wells, and of the pine belt of southern New Jersey and its water supply; and Mr. Jenkins writes of the industries before noted.

In an appendix of 102 pages, Mr. Pinchot contributes "A Study of Forest Fires and Wood Production in Southern New Jersey," illustrated by twenty-three plates. This work is partly to be incorporated in the same author's handbook of forestry soon to be issued by the United States Department of Agriculture. W. U.

Origin of Grahamite. By I. C. WHITE. (Bull. Geol. Soc. Am., 10, 277-284.)

The grahamite of Ritchie county, West Virginia, first described by Lesley in 1863, and more fully by Fontaine in 1873, fills a vertical fissure about two-thirds of a mile long, varying in width from a few inches at the ends to 4 and 5 feet in the middle. The fissure is at right angles to and undoubtedly genetically connected with the Burning Springs-Eureka anticlinal which, with dips of from 30° to 70°, crosses the formation about 7 miles west of the deposit. Lesley predicted that "this gash was once an open fissure communicating with some reservoir of coal oil (petroleum) which still, it may be, lies beneath it undisturbed." Oil wells drilled during the past decade have fully verified this prediction, developing at a depth of 1,500 to 1,600 feet and in close proximity to the grahamite fissure, a pool of oil which is but part of the prolific Cairo oil field. Hence the author concludes that there can be no doubt whatever that the fissure made by tension from the Burning Springs-Eureka uplift was filled with petroleum from this pool, and that subsequently the oil was gradually converted by oxidation from infiltrating water into grahamite without any heat other than that afforded by the normal temperature of the earth. In this connection he cites Jeaney's experimental production of grahamite by passing heated air through petroleum for several hours. As a corollary from this conclusion, albertite, gilsonite, uintaite, and practically all forms of asphalt, including, as suggested by Diller, the "pitch" coal of Coos bay, Oregon, are oxidized petroleum, and the wonderful deposit of asphalt on the island of Trinidad is regarded as an old oil pool uncovered by erosion and hardened by volatilization and oxidation. W. O. C.

A Contribution to the Study of Contact Metamorphism. By J. MORGAN CLEMENTS. (Am. Jour. Sci, 157, 81-91.)

This paper is essentially a detailed account of a somewhat normal instance of contact metamorphism not hitherto described. It occurs in the Lower Huronian iron-bearing formation of the Crystal Falls district of the upper peninsula of Michigan, where the Mansfield slate formation of the Michigamie Valley is cut by large and continuous masses of coarse doleryte (diabase). The intrusions show no evidence of endomorphic action and are not described; but the slate, which is an undoubted sedimentary deposit, exhibits, as we approach the igneous contact, increasing metamorphism, and the successive phases known as phyllytes, spilosytes, desmosytes, and adinoles are observed in normal order. The least altered rocks, the normal clay slates, are found on microscopic examination to be of a semicrystalline character, containing, besides clastic quartz and original interstitial matter, secondary white mica, rutile, hematite, and actinolite. The phyllytes are similar, except that they are more lustrous, and the interstitial material has been changed to white mica. The spilosytes, desmosytes, and adinoles are the true contact products. They are dense, flinty, "hornstone-like" rocks, which show in some cases the fine banding of the original slates, while others are very characteristically spotted. The mineralogical components are quartz, feldspar (albite), biotite, chlorite, white mica, actinolite, rutile, epidote, and iron oxide. In the first two varieties chlorite is the chief dark constituent with little or no actinolite, while the opposite relation holds for the adinoles. Complete analyses by George Steiger and H. N. Stokes are given for the normal clay slates, spilosytes, and adinoles. A comparison of the analyses shows a marked increase of silica as the doleryte is approached, and a corresponding diminution of alumina and iron as well as of water and carbonaceous matter. The most noteworthy contrast between the clay slate and the contact rocks is shown in the relations of potash and soda. For the clay slate the percentages are 5.73 and 0.54, respectively, while in the contact rocks these proportions are reversed, the successive values for potash being 0.70, 0.22, 0.15, and for soda 6.72, 8.22, 6.57. This agrees with the fact that, while albite is wanting in the clay slate, it is an abundant constituent of the contact rocks. The author concludes that the changes in ultimate chemical composition are probably best explained as due to an actual transfer of material, possibly in the form of a soda silicate, from the basic igneous rock to the intruded slate. W. O. C.

The Petrograpical Province of Essex County, Mass. By HENRY S. WASHINGTON. (J. Geol., 6, 787-808; 7, 53-64, 105-121, 284-294.)

Although Essex county is a region of great petrographic diversity and interest, and its rocks have received much attention from geologists in the past, and are the subject of a considerable literature, this series of papers is the first systematic and comprehensive petrological study of this now classic area. The author confines his attention to the igneous rocks, which include chiefly granites, quartz-syenytes, syenytes, nepheline-syenytes, essexytes, diorytes, and gabbros, cut by numerous dikes and with later flows of rhyolyte. The entire series is regarded as pre-Carboniferous and post-Cambrian, having cut and metamorphosed the Cambrian strata of the region. The descriptions are supplemented by chemical analyses and a general discussion of the results, including a comparison of this region with others of similar character. The granites are all hornblendic, but contain also more or less glaucophane and biotite, and the accessories include danalite, fayalite, allanite, epidote, zircon, magnetite, apatite, fluorite. The feldspar is all of the most acid alkali varieties, including orthoclase, microcline, and albite, occurring largely as highly typical microperthites and cryptoperthites. The analysis shows a typical acid granite, rich in potash and low in lime and iron oxides. The mineralogical composition, as for most of the rocks studied, is calculated from the analysis. Included masses of darker color and finer grain are found to consist of the same essential minerals as the granite, but in different proportions, analysis showing 10 per cent. less silica and much more iron oxide, corresponding to a quartz-syenyte. Alkenyte, or augitic quartz-syenyte is found to be almost as abundant as the granites, and the analysis shows it to be closely similar in composition to the dark inclusions of the granite, and like these it is regarded as a differentiation of the granite magma. Another very slight differentiation is afforded by the nordmarkyte or mica-hornblende-quartz-syenyte, and the more acid character of this type finds mineralogical expression in the substitution of biotite and hornblende for augite. More strongly contrasted with these, and with an unquestionable claim to separate recognition is the nepheline syenyte, which has, in comparison, a rather limited development. Two main structure types are recognized, a granitic and a trachytic, which shade into each other and correspond to the ditroyte and foyayte of Brögger, the latter predominating. An analysis is given for each type, the only notable difference being that the foyayte is rather richer in soda and poorer in iron oxide than the ditroyte, while both are notably poorer in lime and magnesia than the nepheline syenytes of other regions, and higher in silica than the average, agreeing closely with the albite-rich litchfieldyte of Bayley. Next comes, as a facies of the nepheline syenyte, and showing the same structural distinction, the nepheline-poor to nepheline-free rock known as pulaskitic syenyte or pulaskyte. An analysis of each phase of this rock shows that it is decidedly more acid than the normal type of nepheline syenyte. This series closes with the orbicular syenyte, which occurs as rounded inclusions in granite and owes its name to the fact that each prominent phenocryst of hornblende is surrounded by a narrow zone of white feldspar. Essexyte, described as essentially a basic monzonitic rock containing both lime-soda and alkali feldspars and feldspathoids, is confined to the immediate vicinity of Salem Neck. It is quite distinct from the nepheline syenytes, by which it is cut, but grades into the diorytes. Sears regards it as the earliest crystallized and most basic portion of the nepheline-syenyte magma. Several structural and mineralogical varieties are recognized, and an analysis of a specimen selected by Sears as representing the type shows a decidedly basic rock (SiO_2, 46.99) rich in lime and soda. Dioryte has a large development in Essex county. It is highly varied and represents transitions from the essexytes to the akerytes. The analysis shows a rather basic rock for a dioryte (SiO_2, 51.82), but, on the other hand, both the silica and alkalies are too high for a gabbro. Besides the main type of dioryte, which is often more or less quartzose, the author describes a quartz-augite-dioryte and a porphyritic dioryte, with an analysis of the latter. The gabbro of Nahant is next described, and the analysis shows that it is low in silica (43.73) and rich in lime (10.99) as a gabbro should be, but also rather poor in magnesia, high in titanium oxide and alumina, and rather high in alkalies, for a gabbro. The hyperitic essexyte of Rosenbusch, called also hyperitic dioryte in one of the earlier papers of this series, is shown by a later analysis to be more properly a hornblende-gabbro (SiO_2, 45.32). The dike rocks next receive attention, beginning with the granitic dikes. These include aplyte, the very narrow dikes of which are wholly confined to the granite, with which they are found to agree closely in composition, and quartz-syenyte-porphyry, which is found to be essentially identical in composition with the nordmarkyte. The rocks of the paisanyte-sölosbergyte-tingnayte series all form dikes, although of paisanyte but a single dike has been observed, the analysis of which is almost identical with the aplyte. The sölosbergyte forms numerous dikes, which are described in detail, with two original analyses and one quoted from Rosenbusch. Three tingnayte dikes are described, with two analyses, the more basic analysis representing an analcite tingnayte. The basic include dikes of camptonyte (one analysis), vogesyte, very numerous dikes of diabase (one analysis), and dikes of labradorite porphyry or porphyritic diabase. The work closes with a brief account of the extensive rocks, including the rhyolyte and keratophyre of Marblehead Neck, and with an analysis of each. W. O. C.

A contribution to the Geology of the Pre-Cambrian Igneous Rocks of the Fox River Valley, Wisconsin. By SAMUEL WEIDMAN. (Wis. Geol. and Nat. Hist. Survey, Bull. No. 3, Science Series No. 2, 1-63.)

The areas of igneous rocks described in this paper are a part of the cordon of hills and ridges of pre-Cambrian rocks that lie outside the more continuous crystalline core of central and northern Wisconsin. These outlying hills were islands in the early Paleozoic seas, and around them are deposited the later horizontal formations of sandstone and limestone. Among the pre-Cambrian outliers are to be found rocks of both sedimentary and igneous origin; but those of the Fox River district are wholly igneous, of both plutonic and volcanic nature. Three types are described in great detail, viz., the Utley metarhyolyte, Berlin rhyolyte-gneiss, and Waushara granite. They are regarded as of Keweenawan age, and the close agreement of the bulk analyses shows that they are essentially consanguineous and belong with the Baraboo rhyolyte to a petrographic province of considerable extent. The acid character of these rocks limits the mineral composition chiefly to quartz and feldspar. An analysis of the feldspar phenocrysts of the Utley metarhyolyte shows that they are a soda-lime feldspar with a considerable amount of potash; and in harmony with this composition, the microscope reveals in most cases a microperthitic structure. This is discussed at some length and shown to be partly original and partly secondary; and the latter is believed to be due in part to an enlargement or outgrowth of the original plagioclase phenocrysts, and in part to intergrowths or regeneration of older plagioclase, the latter process being regarded as allied to paramorphism and not unlike the process of schillerization as described by Judd.

W. O. C.

MONTHLY AUTHORS' CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Bailey, E. H. S. (G. P. Grimsley and)

Special report on Gypsum and Gypsum cement plasters. (Kans. Univ. Geol. Sur., vol. 5, pp. 183; plates and maps, Topeka, 1899.)

Beecher, Chas. E.

Othniel Charles Marsh. (American Geologist, vol. 24, Sept. 1899, pp. 135-157, portraits.)

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*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Blake, W. P.

Aboriginal Turquoise mining in Arizona and New Mexico. (Am. Antiquarian, vol. 21, Sept. 1899, pp. 277-284.)

Blue, Archibald.

Report of the Bureau of Mines (Ontario), vol. 8, part 1, pp. 120, Toronto, 1899.)

Bow, James A.

Mines of Northwestern Ontario. (Rep. Bureau of Mines, vol. 8, part 1, pp. 48-100, 1899.)

Darton, N. H.

Bad lands of South Dakota. (Nat. Geog. Mag., vol. 10, Sept., 1899, p. 339, plates.)

Emerson, B. K.

Geology of old Hampshire county, Massachusetts, comprising Franklin, Hampshire and Hampden counties. Mon. 29, U. S. Geol. Sur., pp. 790, 35 plates, Washington, 1898.

Emmons, S. F.

[Introduction to] Geology of the Aspen mining district, by Spurr. (Mon. 31, U. S. Geol. Sur., Washington, 1898.)

Grimsley, G. P. (and E. H. S. Bailey.)

Special report on Gypsum and Gypsum cement plasters. (Kans. Univ. Geol. Sur., vol. 5, pp. 183; plates and maps, Topeka, 1899.)

Grant, U. S.

The Geology of Itasca county. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 168-211, 1899.)

Grant, U. S.

The Geology of Cook county. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 313-345, plates, map, 1899.)

Grant, U. S.

The Geology of the Pokegama Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 346-349, map, 1899.)

Grant, U. S.

The Geology of the Grand Rapids plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 350-354, map, 1899.)

Grant, U. S.

The Geology of the Swan Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 355-357, map, 1899.)

Grant, U. S.

The Geology of the Gabbro Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 399-419, map, 1899.)

Grant, U. S.

The Geology of the Snowbank Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 420-433, map, 1899.)

Grant, U. S.

The Geology of the Fraser Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 434-461, map, 1899.)

Grant, U. S.

The Geology of the Akeley Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 462-480, map, 1899.)

Grant, U. S.

The Geology of the Gunflint Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 481-490, plate, map, 1899.)

Grant, U. S.

The Geology of the Rove Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 491-495, map, 1899.)

Grant, U. S.

The Geology of the Mountain Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 496-501, map, 1899.)

Haworth, Erasmus.

[Introduction to] Special report on Gypsum and Gypsum cement plasters. (Kans. Univ. Geol. Survey, vol. 5, Topeka, 1899.)

Haworth, Erasmus.

Annual Bulletin of the mineral resources of Kansas. Univ. Geol. Sur. Kans., pp. 118, plates 21, Lawrence, July, 1899.

Hershey, O. H.

Correlation in the Ozark region; A correction. (Am. Geol., vol. 24 pp. 190-192, Sept. 1899.)

Hill, Benj. F.

Notes on a set of rocks from Wyoming. (School Mines Quart., vol. 22, pp. 357-364, July, 1899.)

Hubbard, Lucius L.

Keweenaw point with particular reference to the Felsites and their associated rocks. (Geol. Sur. Mich., vol. 6, part 2, pp. vii and 155, 10 plates, maps, Lansing, 1898.)

Kemp, J. F.

A brief review of the titaniferous magnetites. (School Mines Quart., vol. 22, pp. 323-356, July. 1899.)

Kirk, M. Z.

Kansas salt. (Univ. Geol. Sur. Kans., Ann. Bul, Mineral Resources, 1898, pp. 68-86, July, 1899.)

Kümmel, Henry B.

The extension of the Newark system of rocks into New York. (Ann. Report, State geologist of New Jersey for 1898, pp. 45-57, plate 2, 1899.)

Lane, Alfred C.

Geological report on Isle Royal. (Geol. Sur. Mich., vol. 6, part, pp. xv and 281, 16 plates, maps, Lansing, 1898.)

Manson, Marsden.

The evolution of climates. (continued.) (Am. Geol., vol. 24, pp. 157-180, Sept., 1899.)

Newberry, J. S.

The later extinct floras of North America. Mon. 35, U. S. Geol. Sur. edited by Arthur Hollick, pp. 151, plates 58, Washington, 1898.

Pearson, H. W.

Is the so-colled "upheaval of Scandinavia" apparent or real? (Am. Geol., vol. 24, pp. 192-196, Sept. 1899.)

Perkins, Geo. E.

Fire brick and clay industry; the iron mining industry. (Ann. Rep., State geologist of New Jersey for 1898,pp. 197-244, 1899.)

Salisbury, R. D.

The soils of New Jersey and their relation to the geological formations which underlie them. (Ann. Rep., State geologist of New Jersey for 1898, pp. 1-41, map, 1899.)

Scudder, S. H.

The Pleistocene beetles of Fort river, Massachusetts. (Geol. of Old Hampshire county, by Emerson, Mon. 29, U. S. Geol. Sur., pp. 740-746, plate, 1898.)

Smock, John C.

Annual report of the state geologist (New Jersey) for the year 1898, pp. 102, maps and plates, Trenton, 1899.

Spurr. J. E.

Geology of the Aspen mining district, Colorado, with Atlas. U. S. Geol. Sur., Mon. 31, pp. 260, 44 plates, Washington. 1898.

Taff, J. A.

Albertite-like Asphalt in the Choctaw nation. (Am. Jour. Sci., vol. 8, Sept., 1899, p. 219-244.)

Todd, J. E.

The Geology of Hubbard county and the northwestern portion of Cass county. (Final report, Geol. Nat. Hist. Sur. Minn., vol iv, pp. 82-97, plates and map, 1899.)

Todd, J. E.

Norman and Polk counties. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 96-116, map, 1899.)

Todd, J. E.

The Geology of Marshall, Roseau and Kittson counties. (Final report, Geol. Nat. Hist. Sur. Minn., pp. 117-131, 1899.)

Todd, J. E.

The Geology of Beltrami county. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 131-165, plates and map, 1899.)

Upham, Warren.

The Geology of Aitkin county. (Final report, Geol. Sur. Minn., vol. iv, pp. 26-54, map, 1899.)

Upham, Warren.

The Geology of Cass county and of the part of Crow Wing county northwest of the Mississippi river. (Final report, Geol. Sur. Minn., vol. iv, pp. 55-81, map, 1899.)

Vemeule, C. C.

Water supply from wells. (Ann. Rep., State geologist, [New Jersey] for 1898, pp. 145-182, 1899.)

Vermeule, C. C.

The Pine belt of Southern New Jersey, and water supply. (Ann. Rep., State geologist of New Jersey for 1898, pp. 183-193, map, 1899.)

Ward, Henry L.

Notice of a new meteorite, from Murphy, Cherokee Co., N. Carolina. (Am. Jour. Sci., vol. 8, Sept., 1899, p. 225.)

Whiteaves, J. F.

The Devonian System in Canada. (Am. Assc. Adv. Sci. address of the vice-president of section E, Columbus, O., Aug. 21, 1899; Am. Geol., Oct., 1899.)

Winchell, H. V.

Minnesota iron mining economically and statistically considered. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 581-616, plates, map, 1899.)

Winchell, N. H.

The Geology of Minnesota; vol. iv of the Final Report of the Geological and Natural History Survey, pp. xx and 629, 31 colored geological plates, 48 plates of photographic views, 114 figs. St. Paul, 1899. With reports of assistants.

Winchell, N. H.

The Geology of Carlton county. (Final report Geol. Survey of Minnesota, vol. iv, pp. 1-24, map, 1899.)

Winchell, N. H.

The Geology of the southern portion of St. Louis county. (Final report Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 212-221, plates, map, 1899.)

Winchell, N. H.

The Geology of the northern portion of St. Louis county. (Final report, Geol. and Nat. Hist. Sur. Minn., vol. iv, pp. 222-265, plates, map, 1899.)

Winchell, N. H.

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The Geology of the Dunka River plate of the Mesabi iron range. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 390-398, map, 1899.)

Winchell, N. H.
The Geology of the Pigeon Point plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 502-521, plate, map, 1899.)

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The Geology of the Vermilion Lake plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 522-549, plates, map, 1899.)

Winchell, N. H.
The Geology of the Carlton plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 550-565, plates, map, 1899.)

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The Geology of the Duluth plate. (Final report, Geol. Nat. Hist. Sur. Minn., vol. iv, pp. 566-580, plates, map, 1899.)

Woolman, Lewis.
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PERSONAL AND SCIENTIFIC NEWS.

The Geological Mapping of the Algonkian gold-bearing rocks of Nova Scotia, under the direction of Mr. E. R. Faribault of the Geological Survey of Canada, has been practically finished as far west as the latitude of Halifax. It gives the positions of anticlinal and synclinal axes, and the locations of the domes along the former, so characteristic of the country, on the scale of a mile to the inch. In addition to this work, which is plotted from sheets of the usual size, special maps are prepared of prominent or complex mining regions which are always on these domes. These maps are uncolored and are printed on sheets of various sizes, upon the scale of 500, 250, or 125 feet to the inch. Mr. Faribault's work during the present field season has included Renfrew, Uniacke, and South Uniacke.

Prof. J. C. Branner, of the Stanford University, writes from Bahia, Aug. 29th that, after a visit to the coral reefs south from Bahia, he will return to San Francisco, via straits of Magellan, Valparaiso and Panama, returning home as fast as possible. He is highly pleased with the results of his examinations, thus far, and expected to finish the work as planned before he leaves the South American coast.

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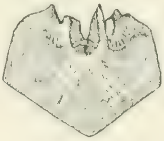

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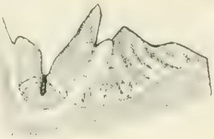

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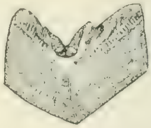

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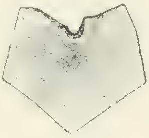

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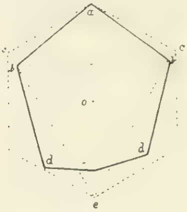

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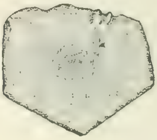

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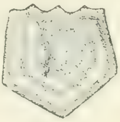

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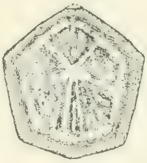

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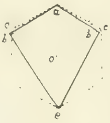

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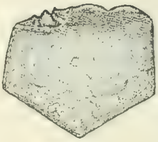

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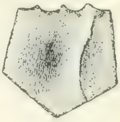

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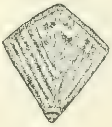

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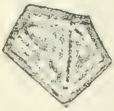

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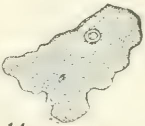

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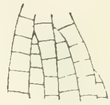

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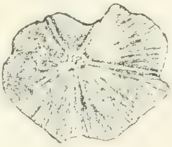

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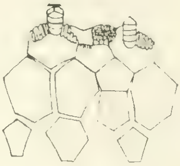

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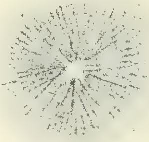

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STROPHOCRINUS DICYCLICUS, gen. et. sp. nov.

THE

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A NEW CYSTOCRINOIDEAN SPECIES FROM THE ORDOVICIAN.

By F. W. SARDESON, University of Minnesota.

(Plate XII.)

In the Galena (Trenton) series of the Ordovician at Saint Paul, Minnesota, isolated large plates of a crinoid occur, which are striking objects to the collector of fossils. They have been found also at Ellsworth, Wisconsin. These plates are well ornamented, thick, and about one inch wide,—larger in fact than the whole calyx of any known associated crinoid. They occur in the zone called the Stictopora bed, associated with conglomerate and with concretionary or oölitic limonite in the clay-shale of this bed. The conglomerate is evidently a corrosion product, and it is probable therefore that this crinoid lived here only during periods of non-deposition of sediment. Its habitat was most probably near the oceanic litoral zone, among reefs, in shallow water. The character of the sediments and the nearness of the localities where it is found, to the supposed Ordovician shore line to the northward, accord with that theory.

The isolated plates were at first identified as those of some large individual of Carabocrinus vancourtlandti Bill., a rare, and unfortunately, little known species from the Trenton stage of Canada. They belong, however, neither to Carabocrinus nor to the species C. vancourtlandti, but they are nearest that species.

The species seems to be a more than ordinarily important one, especially since it belongs neither to crinoids proper nor to cystids but rather to both. It is unlike other cystocrinoidean species such as Cariocrinus in having no pores nor diplopores or pore rhombs on the calyx below the bases of the arms. It may be even contrasted with Porocrinus, which is crinoidean in the arrangement of the plates but has distributed pore-rhombs. The new species is without the same pore-rhombs but yet preserves cystidean asymmetry on one side of the calyx in the arrangement of the plates and also in the development of the arms. In most characters it is like Carabocrinus, a crinoid according to authors.

STROPHOCRINUS DICYCLICUS, gen. et sp. nov.

(Plate XII.)

There are five infrabasal plates and these are apparently the homologue of six, i. e., there are four equal quadrangular plates, and the fifth is in size, shape and ornamentation like two anchylosed quadrangular ones, being pentagonal or rather, hexagonal with one angle a little re-entrant (see fig. 1). The circle of five infrabasals forms a hexagonal field as in Carabocrinus et al.

The basals are large, hexagonal or heptagonal but owing to the obtuseness of the inferior angle are approximately pentagonal and hexagonal respectively. There are six plates in the circle of basals, one of which is smaller than the others and corresponds to the posterior basal in position. It is hexagonal. The next ones to it are heptagonal and the other three hexagonal.

The next circle comprises about ten plates, nine of which are evident on the type specimen (see figs. 1 and 2), but are in part broken away. In general the anterior side is symmetrical and the posterior side asymmetrical as compared to the formula for Crinoidea. The anterior, symmetrical side preserves one radial upon which remain two brachials and a part of the third. None of the unbroken plates on the posterior side can be considered radials. The other plates require reconstruction, which in a partly crushed specimen offers some difficulty. But upon comparing the isolated plates at hand with those of the type specimen, it is found that they match well each with some one, and that they are sufficient to afford duplicate of every whole plate with others remaining for comparison with the fragmentary radials. By aid of these a reconstruction has been made (fig. 2) with as great accuracy as

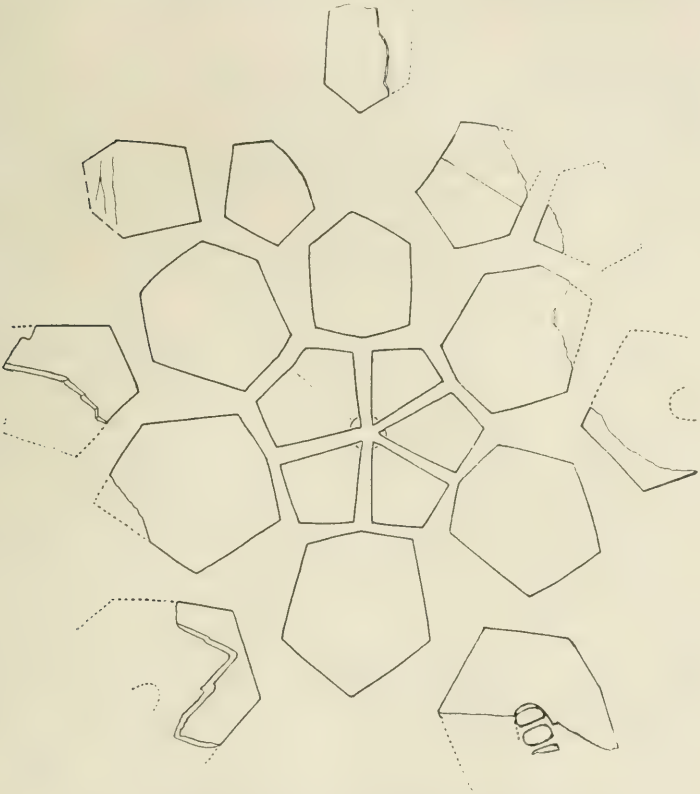


Fig. 1. Diagram of Strophocrinus dicyclicus, drawn to show relation of the basals.

practicable. In this, however, exactness is neither possible nor necessary, since the plates evidently vary in shape, as is shown especially by the heptagonal basals of which there are found both wider and narrower ones than those of the type specimen. The shape of the fragments of the plates reconstructed has however not been changed in the drawing as shown in the figures 1 and 2.

Only three arm-bearing radial plates are evident and these appear to represent, besides the anterior radial, the left and right anterior ones,—see figs. 1 and 3, pl. xii and fig. 1 and 2.

Two other radials do not bear the arms, or they support them in part only, and in that case also the arms must have been small. These posterior radials are much alike except in size.

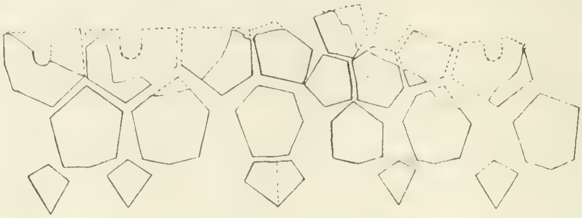


Fig. 2. Formula of Strophocrinus dicyclicus, showing the relation of the radial plates.

Between the right and left posterior radials are the azygous plates of which three are pentagonal, a fourth is hexagonal, representing apparently two anchylosed pentagonal plates, and a fifth one,—is constructed out of whole cloth, there being no such small quadrangular plate yet in the collection. The sixth azygous plate as usually designated, has already been counted as a basal. It is the large heptagonal plate on the left side (in figs. 1 and 2) of the small "posterior" basal, otherwise the "right" posterior basal; and besides this there is a seventh representative in the smaller half of the pentagonal right posterior infrabasal.

The type specimen has enough of one arm to show that it was comparatively slender and that if it branched at all, the branching was not below the third brachial. Only the outer side of the arm is free from the matrix and what is known further of it has been learned only from isolated radials. These have a well defined articular area, bearing two cog-like ridges and a single medium groove, as figured, pl. xii, figs. 1, 2, 3, and bearing also a raised horseshoe-shaped rim. Above the centre, of the articular area, as indicated by the converging processes, the radial plate is notched, and this notch is the only feature that marks also the inner side of the radials; where it has a raised rim, fig. 4, pl. xii.

The plates are often highly ornamented by abruptly elevated warts and these are either distributed or are arranged in rows or form ridges. This ornamentation builds a double system of rhomboidal areas the one around the angles of the plates, the other with the centres of the plates as centres, the two systems confusing. In each, the outermost or bounding ridge or row of warts is most conspicuous. The radial plates are least ornamented, scarcely at all so, in fact, above their mid-hight.

No water vascular pores nor diplopores have been detected on the "patina" although closely searched for. Two pores which are easily seen in the lower angle of each infrabasal and which lead within the articular area of the column are very evidently not diplopores. But on the other hand, certain furrows on the outer surface of well preserved radials may be of the nature of "rhombs," although not accompanied by perforations of the plates. As shown in figures 1, 2 and 3, pl. xii, these structures extend between the bases of the arms. Weathering soon obliterates them as it has on the type specimen. Carabocrinus appears to have similar structures, see fig. 18, pl. xii.

Returning now to the supposed posterior radials which do not bear large arms—their identification is based upon the existence of a truncated side and the nearly smooth surface next the same, and also upon the appropriate shape. They would not fit into the calyx except as placed. But most of all, they are identified by the existence of a notch, especially on the right posterior one, which has an interior raised periphery (fig. 5, pl. xii), and with which is associated on the outer side one of the peculiar water vascular areas or rhombs (fig. 6, pl. xii). The left posterior radial is marked by a less distinct notch and rhomb, but has shown, pl. xii, fig. 8, by the three specimens a fracture-like mark on the otherwise smooth inner side. I do not understand its significance, merely having observed that it ends in the same direction as the marginal notch. The right posterior radial, its mate, bears a similar but less prominent scar, running a little differently at the lower end.

The ventral side, very probably, was covered with smaller plates, whence the scalloped margins of the radials. The scallops are, however, not alike on duplicates of the same radial, and it must be believed, therefore, that the small ventral plates like the sutures were far from uniformly arranged.

If the above interpretations be correct, this crinoid was in most essential features like the Cyathocrinidæ, especially

Carabocrinus. But there is a greater number of azygous or anal plates than in those, and the same are large. Five radiating ambulacral furrows were evidently developed, and of these the anterior one certainly ended in a well developed arm, which, however, articulates to a comparatively small area near the centre of the radial plate. The right and left anterior furrows evidently united with arms and radial plates like the anterior one. The right and left posterior radials, as reconstructed, have the ambulacral furrows scarcely encoaching upon their margin. By close search, it has been found that a slight indication of a small articular area is sometimes preserved on these, and it is believed therefore that the posterior ambulacral furrows ended in small free arms, which, however, were based in part only, when at all, upon the radial plates. There are, thus interpreted, five arms, three anterior large crinoidean ones and two posterior smaller cystocrinoidean ones. Conservatively, however, it must be said that we have proof of but one arm, and partial proof of the others.

The stem was slender, as shown by a small piece which is preserved on the type specimen. Where this piece is broken off, one can see that it is evidently composed of five columnals in each segment. It united to a distinctly impressed articular area on the calyx, which appears also on isolated infrabasal plates, fig. 10, pl. xii, the shape of this area and of the acute lower angle of the infrabasals, indicating, moreover, that the communication between the hollow of the stem and the interior of the calyx was through the pores or perforations, of which there is one pair on each infrabasal. The double-sized infrabasal bears two pores belonging to one-half and a wart or fascet, not perforated, on the other half nearer the margin of the articular scar. In fact, the angles of the two supposed anchylosed plates here do not coincide, the left half of the plate, bearing the wart, has the position of the lower angle pushed back or away from the stem's centre. On fig. 11, pl. xii, the angle of the right half is broken away and the pores lie on the fractured edge.

An associated disc-shaped root or stump is probably the base of this species' stalk. On the dark stained limestone pebbles before mentioned occur not rarely circular blacker areas, fig. 17, pl. xii, with radiating ridges and a central spot.

These fossils are not unlike fossil medusæ in a gross way, but they have a pentameral symmetry. Rarely, the black film-like coating may be thicker and with increasing thickness the dark color lessens. The best specimens are low, conical, whitish lime bodies with crystalline cleavage, smooth surface and central stump of a broken off crinoid stem. When well preserved the surface, if dampened, shows suture lines (figs. 14, 15, pl. xii), and the disc is seen to be composed of radiating rows of plates with close sutures. Another specimen (pl. xii, fig. 16) has an etched or macerated surface on which ridges occupy the position of the radiating rows of plates and branching furrows between them mark the sutures. Transverse sutures also appear on the macerated surface, but much less distinctly than the radiating ones. In the first stages of maceration, apparently, the furrows along the transverse and the radiating sutures are equally deepened, but later the latter rapidly exceed the former, probably because they merge into parallel internal canals. Five ridges or corresponding five primary rows of plates arise from the central stem or stump and radiate to the margin. Other ridges or rows of plates intercalate between them. The furrows or suture lines branch correspondingly. The arrangement of the plates and sutures around the stump or base of the stem is unfortunately obscured in all my specimens by discoloring or by injury, but very probably they simulate a crinoidean or cystidean calyx. Also it is not readily determinable in the specimens whether the disc comprises one or two or three layers of plates, except that one of the stumps indicates two layers. The margin of the disc may be partly lobate, or may be far from circular as in the specimen figured (pl. xii, fig. 14). In this case the rows of plates may be not very regular, as in one place where the rows intercalate in such a manner that there seems to be only one plate in each row. Normally, the structure is comparable to a crinoidean stem base with numerous branching laterally appressed cirri.

Discussion.

This new crinoid is especially interesting when compared to both Crinoidea and Cystoidea. As well known, the Crinoidea are now thought to have been derived from the Cystoidea, and in that relation the Cystocrinoidea or crinoidean

Cystoidea are classed as nearest Crinoidea. Of the cystocrinoidean genera Cariocrinus and Porocrinus come into consideration most appropriately here. The latter genus differs from true crinoids only in the possession of pore-rhombs or water vascular organs on the abactinal wall of the calyx. Cariocrinus differs in that way, and also in the greater number of ambulacral furrows and arms and radial plates. Compared to these Strophocrinus n. gen. shows no pores nor rhombs below the bases of the arms, although structures comparable to rhombs overlap upon the upper edges of the radials. In this respect, it is like Carabocrinus, if the drawings by W. Billings are rightly understood (see fig. 18, pl. xii), but is none the less intermediate in type between Crinoidea and cystocrinoidean Cystoidea. In Strophocrinus, three arms and radials are crinoidean and are accompanied by complete crinoidean symmetry on the anterior side of the calyx. Two arms and radials are cystocrinoidean, and they are associated with posterior azygous or supernumary plates among the radials, with a sixth basal and anchylosed sixth infrabasal. These characters are like Cystocrinoidea possess, e. g. Cariocrinus, and yet differ from structures in certain Crinoidea, not in kind but rather in degree. In Carabocrinus, fig. 18, pl. xii, a less complete but homologous asymmetry is retained. In Dendrocrinus and Cyathocrinus it is still evident, but reduced.

Strophocrinus stands in the position of an intermediate or link between the composite of Cariocrinus, Porocrinus, et al., and the composite type of Cyathocrinoidea, including Carabocrinus. This places the azygos and anal plates of crinoids in a new light, and requires further explanation.

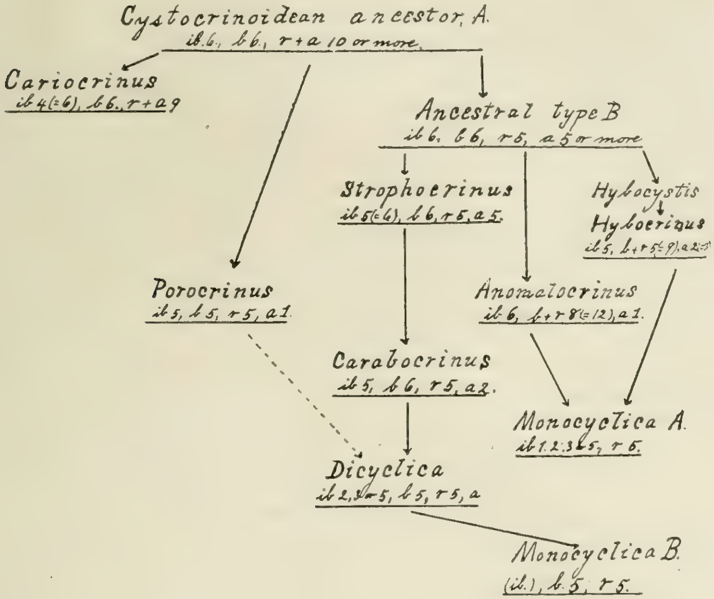
Wachsmuth and Springer, in their "American Crinoidea Camarata," present the generally accepted view which is different from the one just mentioned regarding the azygous plates and space in the Crinoidea. "In all dicyclic crinoids the basals, without exception, consist of five plates, the infrabasals either of five, three, or a single piece," they say (op. cit. p. 54), and in fact this account is skillfully enforced by the interpretation which they outline. They recognize the homologue of five infrabasals, or respectively basals, where a lesser number occurs, the lesser number being interpreted as fusion of adjacent infrabasals or basals. However, "the case is not so simple in genera with an anal plate where the form of the basal disc is changed from pentagonal to hexagonal, as a bisection of the larger plates would produce six plates instead of five." It is necessary for them to explain away the apparent sixth element which they do by ascribing increased width of one plate coinciding with the intercalation of the anal plate. The azygous plates are not considered as primitive, according to that view.

Strophocrinus shows on the contrary that the sixth infrabasal element should be interpreted as an anchylosed plate, where it is evident, and a comparison of Crinoidea to cystocrinoidean types will show that no azygous or anal plates need be viewed as intercalated. Comparison of primitive Cystoidea. with cystocrinoidean types and Crinoidea, shows an evident reduction in number of plates in the abactinal side of the calyx. and further reduction characterizes later crinoidean development. No other explanation for the asymmetry and the azygous plates in Strophocrinus is needed, as it seems, than that the change from the hexamerally distributed arrangement of plates in certain cystids to that of pentameral arrangement and reduced number of crinoidean plates is imperfectly accomplished. From this view point, Strophocrinus appears nearer the true transitional type from Cystoidea to Crinoidea than either Cariocrinus or Porocrinus does, both of which are too far advanced in the reduction of infrabasals to represent the ancestral type of such crinoidea as Carabocrinus. Cariocrinus has four infrabasals, equivalent in dimension to six, i. e., the circle of four build an hexagonal area. Porocrinus has five, equivalent to five. Strophocrinus has five, equivalent to six, as Carabocrinus also has. Crinoidea of course more often have the equivalent of five. The basals also are only five in Porocrinus, although six in Cariocrinus, six in Strophocrinus and Carabocrinus, five in most Crinoidea—always five in these, in fact, if a certain plate be called not a basal. Porocrinus has but one azygous plate, Cariocrinus has the equivalent of several, Strophocrinus has four or five, Carabocrinus has three, and Cyathocrinidæ generally have two or one, i. e., a radianal and an anal plate.

If we represent the cystocrinoidean composite type as ancestral also to Crinoidea, i. e., six infrabasals, six basals, and about ten radials, including azygous plates, then Strophocrinus stands intermediate to that type and Carabocrinus and other Cyathocrinidæ, and it thus indicates what direction a line of evolutionary development may have followed between Cystoidea and Crinoidea. This suggested relationship harmonizes the conspicuous long since recognized (Hall, 1852) relation of the four infrabasals of Cariocrinus ornatus Say., to six hypothetical equal elements, as also the relation of five infrabasals to six elements in Strophocrinus, Carabocrinus, et al. It harmonizes the six symmetrical basals found in Cariocrinus and in Strophocrinus and the same as represented in Carabocrinus. The "radianal," the anal and other posterior azygous plates of the Order Fistulata, as well as the azygous plates in Porocrinus, compare readily to the less reduced structure in Strophocrinus. Even the "supplementary radial" plates of monocyclic Fistulata, which, as we are told, are of great taxonomic importance, might in like manner be compared to the basals, parabasalia, of such a form as Strophocrinus; and in the absence of any evident rudimentary infrabasals in forms closest related to Bærocrinus and Hybocrinus, and in view of the supplementary plates in these being in the position of basals, as seen in Strophocrinus, one might not perhaps be criticised for suggesting that two lines lead from dicyclic to monocyclic forms, the earlier one through reduction of basals, the later one through reduction of infrabasals. In the former the parabasalia fuse with the radials, in the latter the infrabasalia fuse together and form the top of the column.

It may be further noted that pentameral crinoidean symmetry is least, probably also last, developed in the circle of radials, or the equatorial zone of the calyx. Pentameral symmetry seems to have developed from the stalk upwards and from the apex or mouth outwards. Among Cystoidea two, three, four, five and six ambulacral furrows appear, the number being inconstant in some cases. In Strophocrinus the pentameral symmetry of the stalk and of the ambulacra seems much like a coincidence with not yet far developed consequences as to the patina. Even the symmetry of the five arms as far as known is incomplete, the posterior pair being smallest.

The following diagram may represent crudely the suggested relationships:



Regarding the stem of Strophocrinus, there is nothing peculiar in its five column segments. It admits Neumayr's interpretation that this structure is pre-crinoidean, while it does not seem to justify the great emphasis that has been placed by authorities on Crinoidea, on the relation of the sutures and furrows of the column to the infrabasals and "basals." The relation may be here interpreted as follows: In the first place, basals and infrabasals are referable to hexagonal form. The anterior basal (fig. 12, pl. xii) is hexagonal, but approaches a pentagon in dimension; ac = ab = radius of hexagon. The lower two sides dd are conspicuously shortened, hence the pentagonal form. A quadrangular anterior infrabasal, fig. 13, has a similar relation to a hexagon; ac = ab = radius of hexagon, and the lower part of the quadrangle has bb = be, which coincides in proportion with bb = be in fig. 12. Compared to a hexagon and to a pentagonal basal, this infrabasal is a third stage in reduction. If we view the infrabasals as modified pentagonal or hexagonal plates, then we must account for the plates which in such a reconstruction would fill the interval enclosed by them. No such plates are found, nor does the proximal end of the stem fill such a position. It overlaps the infrabasals, not entering its calyx wall. Again, none of the five sutural lines coincide with any of the six sutures of the infrabasals, not even with the obsolete one. This is as would be expected. If the stem of Strophocrinus were restored, quite evidently we should find it with five sutural lines running from top to bottom. It is a flexible structure. Sutures of the calyx on the contrary alternate, forming a rigid structure. A stem made up of hexagonal plates, as Neumayr thought the primitive stem to be, would, if close jointed, be rigid. Early crinoid stems are flexible, jointed structures, and the same type commonly occurs among cystids. If these were derived from an inflexible stem or extension from the cystidean body wall, the transition to the jointed structure would be first vertically compressed hexagonal alternating plates, second, quadrangular plates in circles, forming segments, third, solid rings; which three stages occur among unidentified stems at this locality. If, then, the transverse sections of the stems of Cystoidea and Crinoidea are consequent to the development of flexibility, the stem's distinctness in symmetry and in demarcation from the calyx may be due to that alone. A primitive calyx with more or less than five infrabasals might indifferently attach to a pentameral stem, and as long as the sutures do not correspond between calyx and stem the attachment would be firm.

The associated basal expansions are also instructive. They resemble the one ascribed to Glyptocrinus from the Cincinnati group, figured and described by Wachsmuth and Springer in "Crinoidea Camarata." The periphery is, however, circular when normal. The structure of the base or "dorsocentral" of Barycrinus, described by them, applies well to this one: "The middle part of the truncated lower face is perfectly flat, and there are no traces shown of an axial canal. But in an outward direction we find grouped around a closed centre numerous small canals connecting with the interior. These canals form upon the surface well defined ramifying grooves which pass out to the periphery and seem to communicate with the surrounding water," op. cit. p. 47. This description applies to the one in hand, except that there is no evidence that the canals or grooves open to the exterior except on weathered specimens. There may be a "dorsocentral plate" not here well observed. The 'rami' do not separate, but fuse laterally. In general form this root is even more like the "dorsocentral" of the Antedon larva than is that of Glyptocrinus, and, therefore, somewhat strengthens the comparison of these as made by Wachsmuth and Springer, op. cit., although the large size in this case indicates that the structure was not merely larval.

In structure, the root as a whole resembles also such supposed Cystoidea as Lichenocrinus, and involves that genus in the general morphological comparison. On one side of one of the specimens, as already described, the intercalation of radiating rows of plates is so closely consecutive that the appearance of rows changes to that of distributed arrangement, and then there is a striking likeness to Lichenocrinus. The structure of radiating canals beneath the covering plates, with a furrowed "centrodorsal" plate or layer beneath these in turn, and a central opening leading into a long pentagonal stem composed of circles or sections of five plates each, describes quite evidently both Lichenocrinus and our crinoid root. In the latter the greater size and more numerous plates usually arranged in rows form rather a generic distinction than a discrepancy.

The root of crinoids appears to be the counterpart of the calyx in type of symmetry. If this is true of Lichenocrinus, then the body to which its stem attached would be rather a cystid than a crinoid, as indicated by the dispersed arrangement of the plates. Lichenocrinus is common in the Galena (Trenton) stage of Minnesota, associated with innumerable crinoid and cystid stems of several types, to which in main no calyx is associated among collected fossils. Evidence here admits that Lichenocrinus might be the larval anchor of some one of very different types of Echinoderms. This possibility recalls the very striking well known relation of not only Crinoidea to Cystocrinoidea, but also Asteroidea and Echinoidea to sessile and stalked Cystasteroidea and Cystechinoidea, and may open to speculative consideration the question whether even Asteroidea and Echinoidea of the Ordovician time did not pass through a stalked larval stage and metamorphosis, as Antedon now does. At least Asteroidea were represented then in Minnesota, as is shown by very rare finds.

Plate XII.

Fig. 1. An isolated anterior radial.

Fig. 2. Portion of figure 1 enlarged to show one of the rhomb areas.

Fig. 3. Another radial plate.

Fig. 4. Interior of a radial plate.

Figs. 5 and 6. Interior and exterior of one of the supposed posterior radial plates.

Figs. 7 and 8, The other posterior radial.

Fig. 9. The anterior basal plate.

Fig. 10. An infrabasal with pair of perforations at the lower angle within scar of stem.

Fig. 11. The unequal infrabasal.

Fig. 12. Diagram of the anterior basal of the type specimen.

Fig. 13. Diagram of anterior infrabasal.

Fig. 14. Sketch of root showing stump of the stem.

Fig. 15. Diagram of suture lines on surface of the last, × 5.

Fig. 16. Corroded root. The one limb of the specimen curves under the supporting pebble.

Fig. 17. A much reduced remnant of a root, × ½.

Fig. 18. Carabocrinus, posterior side of calyx, after W. Billings as published by Wachsmuth and Springer in "Crinoidea Camarata," vol. I, figure 2.

NOTES ON THE CORUNDUM-BEARING ROCKS OF EASTERN ONTARIO, CANADA.

By Willet G. Miller, Kingston, Ontario, Canada.

(Plate XIII.)

The writer spent the summers of 1897 and 1898 in a study of the economic geology of part of eastern Ontario for the provincial Bureau of Mines. On beginning the work, he was asked to make an examination of the corundum deposit, the occurrence of which had been reported by Mr. W. F. Ferrier, lithologist of the Canadian geological survey, in the autumn of 1896.

By the time field work was begun, in 1897, another deposit had been discovered. The mineral was found to occur under similar conditions in the two deposits, it being an original constituent of syenyte, syenyte-pegmatite and nepheline syenyte.

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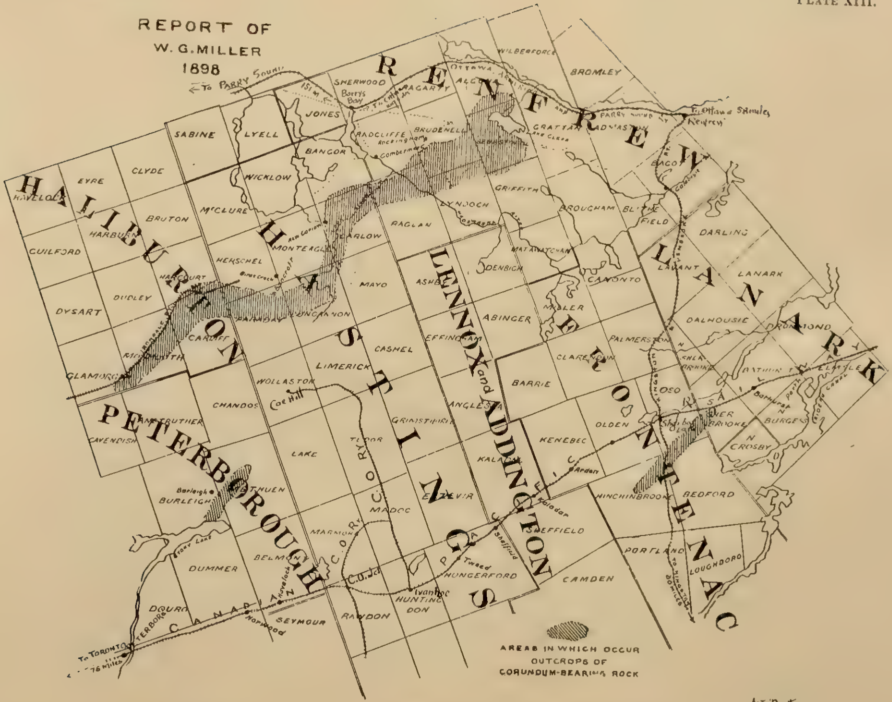

INDEX MAP OF CORUNDUM DISTRICT.

SCALE
Miles 10 5 0 10 20 Miles

Ast. North

Having determined the character of the rock at the two known deposits, other deposits were searched for, and, at the end of the season's field work in 1897, numerous outcrops of these igneous rocks carrying corundum had been found. These outcrops are situated along a belt or strip of country which has a length of about 30 miles and an average breadth of between 2 and 3 miles.

In the report made to the Bureau of Mines in 1897, it was stated that the belt would likely be found to have a much greater length than time had permitted proving during that season, and that what had been considered to be isolated outcrops of syenyte lying farther to the southwest would be found to be part of a belt similar to that already worked out.* On continuing the work in 1898, such was found to be the case. At the end of this season's explorations the strip of country along which outcrops of corundum-bearing rock had been found had a length of about 75 miles. Starting from the eastern end, the belt runs pretty regularly westward for about 30 miles; then it bends rather abruptly to the southward and continues this course to the westward. Neither the eastern nor western extremity of the belt has yet been determined.

This belt forms what may be called a somewhat unique structure in the Archean. It would appear from it that the structure of the Archean is on a larger scale than is usually considered and by studying only minor structures a great deal is lost. Were it not for the presence of corundum, it would be difficult if not impossible to trace up these rocks in the field and to finally prove their relationship, as they possess different characteristics in different parts of the district.

During 1898, the writer traced out two other belts in which corundum-bearing rocks occur. These are each some miles in length. It seeems likely that, had time permitted, they could have been proved to be connected in some way with the main belt. These three strips of country taken together, partly surround a region whose diameter is 50 miles or over. The longest belt bounds the region on the north. One of the smaller belts lies to the southwest and the other to the southeast.†

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*The location of these belts is shown on the index map which accompanies this paper.

†Bureau of Mines, Toronto, 7th Report, p. 229.

Whether, however, if traced out, they would be found to form roughly parallel bands, or, as seems not unlikely, are connected in circular form, is at present impossible to say.

The oldest rock in this Archean region is a dark somewhat basic gneiss, with which is frequently associated crystalline limestone. This gneiss is cut by the igneous series which contains the corundum. These igneous rocks are themselves cut by quartziferous pegmatite and trap dikes.

The corundum-bearing series in the main belt and in the smaller one, which lies to the southwest, consists essentially of syenyte-pegmatite and mica, hornblende and nepheline syenyte. Nepheline, it may be added, is found in some of the pegmatite. These syenytes vary greatly in size of grain and mineralogical composition in different parts of the field. In some cases, the syenyte masses appear to merge gradually into granite, but corundum is absent in this rock. In other cases, well defined dikes of corundum-bearing syenyte occur, which have a width of an inch. It may be stated that in some parts of the main belt the syenyte passes into rocks which are basic in character and appear to have the composition of gabbros or anorthosytes. These latter rocks are at times highly metamorphosed and have been changed into scapolite-bearing varieties.

In the third belt, which has been referred to as lying to the southeast of the main belt, the corundum occurs in outcrops of basic anorthosyte, which were found across country for several miles. At the southwest end of the band, however so far as traced, the mineral again occurs in syenyte-pegmatite similar to that of the main belt. We then have the mineral occurring in the region in rocks which range from those composed essentially of basic plagioclase to those whose chief constituent is alkali feldspar and nepheline.

The anorthosyte band, in places, has a breadth of nearly one mile. So far as observed, this corundum-bearing rock does not occur in narrow dikes as do the syenytes, but in what may more properly be called masses.

As corundum-bearing anorthosyte, so far as the writer is aware, has, up to the present, been found only in Russia and India, it seemed well to give an account of the composition of the Ontario rock in this paper.

On weathered surfaces, the rock is grey or at times somewhat purplish in color. In size of grain, it is medium to coarse. Under the microscope, the most abundant constituent is seen to be a basic plagioclase. Associated with this are black hornblende, which is green in transmitted light, and, in some cases, corundum. This latter mineral, which is almost white or inclining to flesh color, stands up well above the weathered surface of the rock. Its crystals, on which the planes are not well developed, are in the form of thick prisms whose greatest length seldom exceeds one and one-half inches. Frequently the mineral occurs in the form of lumps rather than crystals.

Corundum of similar character is described by Holland as occurring in a rock "consisting of anorthite (indianite) and hornblende chiefly" in India. The specific gravity of a specimen with but little hornblende was found to be 2.824.[*]

It may be added that in the Indian and Russian regions in which corundum occurs in arothosyte, it is also found in syenyte and syenyte-pegmatite. Although nepheline syenyte occurs in the same regions, corundum so far does not appear to have been found in this rock outside of Ontario.

In his description of the corundum-bearing igneous rocks of Russia, Morozewicz states that, although rocks of this character are, at present, so far as is known, of rare occurence, they will be found to occur more widely when search is made for them.[†]

The discoveries of these rocks over such a wide tract of territory, which have been made in Ontario in old settled districts within the last three years confirm the author's opinion.

In Ontario, corundum up to the present has been found in the following igneous rocks, viz: 1. Syenyte (mica, etc.). 2. Syenyte-pegmatite. 3. Nepheline syenyte. 4. Anorthosyte. The following table shows in which of these the mineral has been found in India and Russia according to the descriptions given by Holland and Morozewicz respectively:—

1.	Syenyte	Ontario India Russia

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[*] Manual Geol. India, Ec. Geol. 1898.

[†] Tschermak's Min. Pet Mitt. Band XVIII.

2.	Syenyte-pegmatite	Ontario India Russia
3.	Nepheline syenyte	Ontario, only.
4.	Anorthosyte	Ontario India Russia

The mineral also occurs in another igneous rock in India, viz.: granite. This mode of occurrence has not been observed in Ontario, although the corundum-bearing syenyte appears to shade off into granite in some cases.

Morozewicz proposes the name kystchtymit for the corundum-anorthite rock of Russia. Instead of introducing a new name, it would seem better to use the term anorthosyte, which has long been used by Canadian geologists and others for igneous rock whose characteristic constituent is a plagioclase.

A specimen of the corundum-bearing anorthosyte from the mass in the township of South Sherbrooke was analyzed for me by Mr. Wm. Lawson, B. A. Sc. His results are given in the following table, together with three analyses of rocks of similar chemical composition from other districts. The specimen selected for examination by Mr. Lawson was free from corundum.

	I	II	III	IV
	Seine River	Russia	South Sherbrooke	Ottawa
SiO_2	46.24	46.54	47.32	47.40
Al_2O_3	29.85	30.73	30.36	30.45
Fe_2O_3	1.30	3.23	1.35	0.80
FeO	2.12	1.18	1.55	....
MnO	trace	....	....	....
CaO	16.24	15.45	15.45	14.24
MgO	2.41	1.35	2.44	0.87
Na_2O	1.98	1.36	1.88	2.82
K_2O	0.18	0.52	0.66	0.38
CO_2	1.03	....	0.58	2.00
H_2O	....	0.04	0.10	volatile
Total	101.35	100.40	101.69	98.96
Sp. gravity	2.85	....	2.73	2.73

I. Seine River, Western Ontario. Described by A. P. Coleman in the Journal of Geology of Chicago, Dec.-Jan., 1896. Seine River lies about 800 miles to the northwest of South Sherbrooke.

II. "Anorthit-Hornblendegestein vom Konschekowskoi Kamen im Ural, nach Roth's Berechnung zu 90 Anorthit, 10 Hornblende." Analysis quoted by F. Zirkel, Tschermak's Min. Mitt., 1871, page 62.

III. Township of South Sherbrooke, Eastern Ontario.

IV. Ottawa (formerly Bytown) on the eastern boundary of Ontario. This analysis is by T. Sterry Hunt, who thus describes the specimen examined "a greenish-white granular variety of anorthosite rock, from a boulder near Ottawa, having a density of 2.73. This is a portion of the specimen upon which Dr. Thompson founded the species named by him bytownite.......The rock is coarsely crystalline and made up of black hornblende, with a little sphene, and a white triclinic feldspar, the cleavage surfaces of which are sometimes half an inch broad, and beautifully striated." Geology of Canada, 1863, page 79.

Most writers state that labradorite is the essential constituent of what they call the typical anorthosytes. It would seem that this is owing to the fact that few analyses have been made of these rocks. Moreover, it may be said that only comparatively restricted areas have been examined. The most of Hunt's analyses and those of other workers on this continent were on samples from the district in Quebec which lies adjacent to the St. Lawrence river and from the adjoining region in the United States to the south. The assumption that labradorite is the typical feldspar of these rocks may moreover be due to the fact that most of the areas of anorthosyte, to which attention has been directed, are of large size, and thus, for various reasons, would, on the whole, be more acidic in character than smaller outcrops. From the analyses which have been quoted by the present writer from Ontario and Russia, it would seem that no one plagioclase should be considered the typical constituent of these rocks.

Rosenbusch[*] quotes four analyses of anorthosytes, Kemp[†] three and Adams[‡] two. These range in percentage of silica from 53.42 to 59.

A part of the specimen from South Sherbrooke, the analysis of which has been given, was reduced to powder. The feldspar and hornblende were then carefully separated by means of a heavy solution and subjected to analysis. The feldspar was found to have the composition represented by the formula Ab_1An_4.

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[*] Elemente der Gesteinslehre, pages 151 and 153.

[†] Handbook of Rocks, page 49.

[‡] N. J. für Min. 1893, page 494.

	Bytownite		Hornblende	
	I	II	III	IV
SiO_2	48.12	48.03	41.40	39.58
TiO_2	....	....	....	trace
Al_2O_3	34.54	33.43	15.39	14.91
Fe_2O_3	0.36	....	7.01	4.01
FeO	....	....	7.17	10.67
MnO	....	....	trace	trace
CaO	16.30	16.28	12.53	11.76
MgO	trace	....	10.31	13.06
K_2O	0.15	....	1.56	0.62
Na_2O	1.91	2.26	3.58	2.87
H_2O (Ignition)	none	....	0.81	2.79
Total	101.38	100.00	99.76	100.27
Sp. gravity	2.731	2.735	3.18 at 15°C	3.217 to 3.222

I. Bytownite from the anorthosyte of South Sherbrooke, Ontario.

II. Bytownite, Ab_1An_4, theoretical percentage given by Zirkel (Petrographie, page 221).

III. Hornblende from the anorthosyte of South Sherbrooke.

IV. Hornblende from a hornblende gabbro, quoted by Rosenbusch (Elemente der Gesteinslehre, page 148).

It will be seen that there is a remarkably close agreement between the theoretical composition of the bytownite, Ab_1An_4, as regards the percentages of the silica, lime and alkalis and that of the feldspar from South Sherbrooke. The proportion of alumina in the latter is, however, over one percent higher than that of the theoretical percentage. This may be due to the presence of a small amount of corundum embedded in the feldspar in a very fine state of division as this mineral occurs, as has been stated, in parts of the rock. None of it was identified, however, either by megascopic or microscopic examination in the specimen analyzed. In thin sections, under the microscope, the feldspar is seen to contain numerous crystallite-like inclusions. It is possible that some of these are corundum.

The hornblendic constituent of the anorthosyte is seen by the analysis to have the composition of the typical variety or what is called common hornblende.

ARCHÆOLOGICAL NOTES ON CENTRAL MINNESOTA.

By OSCAR H. HERSHEY, Freeport, Ill.

The vicinity of Little Falls, in the county of Morrison, central Minnesota, has become a well known field of research in American archæology, by reason of the controversy over the significance of the so-called paleolithic types of human implements discovered originally by Prof. N. H. Winchell* and afterwards fully discussed by Miss F. E. Babbitt† and by Warren Upham.‡ Although the glacial age of the implement-bearing material has been scientifically discredited by the work of Dr. W. H. Holmes,§ the question has not been completely settled. As each observer may view the facts in a slightly different light, and hence arrive at conclusions somewhat distinct from those of others, I feel justified in placing before the archæologic public the result of a somewhat desultory investigation, made in the early part of September, 1896, into the distribution and character of the artificially formed fragments of Morrison county.

Geologically and topographically considered, the country included within the limits of Morrison county is a rolling drift plain elevated about 1,200 feet above the sea. In portions it is rapidly undulating, rising into steep morainic ridges and rounded knolls. Crossing it from north to south and lying at a level about 150 feet lower than that of the general upland, there are several flat gravel-and-sand plains. Through the most important of these plains flows the Mississippi river, which has trenched a trough or valley rarely much wider than the stream and usually about 25 to 30 feet in depth. It is on this sand-plain and the steep slopes along the river bank that the quartz fragments which I am going to discuss are found. But before proceeding to their description, it will be well to mention, in somewhat more detail, the general features of the later geologic history of the district.

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*Sixth Annual Report, Geol. Nat. Hist. Sur. Minn., for 1877, pp. 53-64.

†Proc. A. A. A. S., vol. XXXII, for 1883, pp. 385-390; vol. XXXIII, for 1884, pp. 593-599. American Naturalist, vol. XVIII, 1884, pp. 594, 605, and 697-708.

‡Am. Naturalist, vol. XVIII, 1884, pp. 706-708. Proceedings, Boston Soc. Nat. Hist., vol. XXIII, pp. 436-447; May, 1888; reprinted with addition of a glacial map of Minnesota, in Wright's Ice Age in North America, 1889, pp. 538-550. Am. Geologist, vol. XIII, pp. 363-4, May, 1894.

§Am. Geol., vol. XI, pp. 218-240, April, 1893.

The rapidly undulating drift plains above the valley proper were formed at a time when the site of Morrison county was occupied by a portion of a great continental glacier. This was in process of general recession, and when its margin had retreated northward to a sufficient distance to uncover the district, the great streams flowing away from the melting ice deposited the broad plains of stratified gravel and sand before mentioned. As soon as the border of the ice-sheet had moved northward as far, say, as the northern portion of the state, the Mississippi river ceased to deposit gravel and sand in Morrison county, but on the contrary it then began to trench its present trough into the sand-plain. The major portion of the excavation of this trench was accomplished during the earlier portion of the post-Glacial period of geologic time. Later, when the land had become somewhat depressed below its late Glacial altitude, the Mississippi river deposited during flood times a flood-plain of gravelly alluvium. This occurs at various places in the present valley, but is not continuous, existing rather as isolated fragments. It varies in hight from three to eight or ten feet above the low-water level. This modern flood-plain, as we shall see, is of considerable importance to the archæologist.

In several places in Morrison county the post-Glacial Mississippi in trenching its present channel encountered ledges of schistose and slaty rocks, which have formed rapids in its bed. In these metamorphic rocks there are occasional veins of white quartz, which may reach a thickness of several feet, and were especially suited to the needs of primitive peoples. Being the only outcrops of good implement material in a very extensive area, they were much resorted to by the aborigines, who constituted them important "quarry sites." The principal of these was at Little Falls, but several others were established farther down the river, notably at Pike rapids, and at several outcrops of schist and quartz several miles above the mouth of the Two rivers. Many flakes or quartz fragments are found scattered on the surface or in the soil in the vicinity of these quartz outcrops. The question of their age is narrowed to two periods of time, by a circumstance which I shall mention later. It is the purpose of this paper to present evidence on this subject, and I shall, therefore, go into the matter somewhat minutely.

In the town of Little Falls, on the north side of the main east-west street, just east of the bridge, street grading has exposed the following section, beginning at the top:

1. Surface stratum of fine gravel, containing blue-flowered and other old-style crockery ware in fragments, window and bottle glass, many pieces of charcoal, bones, teeth, rusty wire, square iron nails. and other modern town debris, but no quartz.
2. Black, sandy soil (original surface), white quartz fragments.................................. ....3 inches
3. Brown, sandy loam, exposed ....2 feet

Nos. 2 and 3 contain large quantities of sharply angular quartz fragments, mostly of the "flake" variety. The pottery ware belonging to the time of the present generation is somewhat plentiful in the streets in some portions of the town, and is usually of white color and modern patterns. No. 1 stratum evidently belongs to an early date of this town's history. The white quartz fragments in the soil below are older, evidently pre-Anglo-Saxon.

Close to the east end of the dam which has been built on the ledges of rock which formed the original falls or rapids, the surface portion of the glacial sand-plain or terrace is exceedingly well supplied with sharply angular quartz fragments, which, however, decrease in numbers as we proceed away from the vicinity of the rapids. These appear to be confined to the upper two or three feet of the sandy loam, and are particularly abundant in the thin black soil layer. Below the dam there intervenes between the foot of the slope which forms the escarpment of the sand-plain or Glacial terrace and the river a lower flat alluvial plain. This is the Modern or post-Glacial flood-plain of the river, and its surface is about ten to twelve feet above the ordinary stream-level. It extends back from the river several hundred yards in places, and has been laid out in streets and built up with houses. A section of its constituent strata, exposed at the lower end of the rapids, is as follows:

1. Incoherent, light brown, sandy loam with black soil at surface.. 3 feet

2.	Distinctly stratified gravel and coarse sand............	2 ft.
3.	Bed of boulders, cobble and coarse gravel. Drift varieties of all kinds, including Little Falls slate. Forms talus slope of modified drift, indicating thickness of...	4 "
4.	Black slate, cleavage planes nearly vertical; uneven surface; exposed along the water's edge to thickness of between..	1-2 "

In No. 2 there are many pieces of black slate from this Little Falls outcrop, and they are so much decayed as to easily crumble in the fingers. Rounded pebbles of white quartz occur in this stratum, but no angular quartz fragments. In No. 1 no quartz was observed except one piece of sharply angular white flint which was found on the lower side of a projection of the loam, about two feet below the surface. As the stratification disappears below this level, I cannot say that this quartz was not introduced through the decay of the roots of trees. There were a few small pebbles in the same stratum. Close to the dam and, therefore, almost at the very foot of the slope at whose summit the abundantly distributed flakes are found, the section which the river bank makes through the Modern flood-plain, shows in the soil layer small, very sparsely scattered quartz fragments. Walking about on the lower terrace and examining vacant lots and the streets, very few pebbles are observed, but upon ascending to the higher plain, twelve feet above the Modern flood-plain, the surface portion always contains a few quartz fragments, even 600 feet back from the river. About 100 yards east from the east end of the dam, in going from the higher sandy plain with many quartz fragments to the lower plain with few quartz fragments, the contrast is strong, and seems to suggest that the quartz distribution on the Glacial terrace preceded the formation of the lower plain, and also that but little quartz was worked by Indians in this locality since the formation of the modern flood-plain. The time at my disposal was insufficient to determine this question with absolute certainty, and it deserves further investigation. I shall have more evidence on the subject to present in discussing other localities.

Proceeding southward on the west side of the river, angular quartz fragments were observed as follows: (a) A small bunch or "pocket" of sharply angular white quartz in the surface soil of the Modern flood-plain, ten feet above the river, at a point about one-half mile below the paper mill.

(b) Occasionally small angular pieces of white quartz in the soil for several miles along the river bank. No pebbles of other rock species exposed in many holes four feet deep.

(c) Another small pocket of quartz fragments and flakes buried in soil from two to six inches beneath the surface.

These are not generally distributed over an extensive area, but are in small pockets or bunches evidently derived from pebbles picked out of the river bed at the foot of the bank, and roughly fractured close by, the flakes now found being the refuse rejected, the remainder of the material having been removed to the village for finishing. As the fragments occur in the surface portion of the Modern flood-plain, their age is not very great.

Returning to the town and proceeding southward on the road from West Little Falls, we traverse the Glacial sand-plain. Small flakes and other sharply angular quartz fragments are of frequent occurrence. Indeed, for a distance of many miles nearly every step brings some into view. Here and there they increase in abundance, and scores may be in sight at one time. These apparent "pockets" are usually encountered when the road approaches close to the river. A few will be mentioned later.

At the west side of Pike rapids a very interesting archæological locality was discovered. Here there are three well-defined terrace planes developed. The higher one is the Glacial plain of modified drift (sand and gravel), and is about twenty-six feet above the river. The next is the ordinary flood-plain, composed of coarse cobble and boulders below and horizontally stratified sand above. It intervenes between the Glacial terrace and the river at the rapids, and rises eleven feet above the latter. At some distance below this place there is a third terrace plain developed consisting of a flat, swampy, non-timbered flood-plain about two feet above the river.

On the upper plain near its edge there are anywhere within a quarter of a mile of the rapids, frequent quartz fragments, sometimes in bunches, but usually widely and nearly uniformly disseminated. There are many very small chips. At the excavation made by Maj. Pike in constructing his stockade, they appear in the banks. They are also seen at intervals in the road between the Little Two river and Swan river. On the second or eleven-foot terrace their distribution is somewhat different. At one place near the edge of the plain, close to a known vein of white quartz, one foot in thickness, under the present water level, the soil for a length of forty feet and extending back from the edge of the bank at some places to fifteen or more feet, is closely packed with quartz fragments, nearly all of small size, as though flaked off in making arrows. They appear to be confined to the upper six inches of the soil, and are well exposed by a prospector's shaft and a number of smaller excavations. Many of the pieces show evidence of concussion and pressure, but there was nothing in the least resembling an implement. They are not of the ordinary flake shape like the chert fragments from quarry sites in Illinois and Missouri, but are very irregular in form, although quite angular and fresh-appearing, and in one case showing, I think, the effects of pressure applied slowly and for a purpose.

The following apparent differences between the quartz on the lower terrace and those on the Glacial plain were observed: The quartz when freshly quarried has a faint bluish tint and a very slightly translucent lustre. All the fragments discovered in the soil of the Modern flood-plain preserve this appearance of freshness. But, on the upper plain, the quartzes, although equally as transparent, seem to have lost the bluish tinting and somewhat of the translucency, so that they have a more ancient appearance. They are very widely distributed, somewhat uniformly, on the upper plain, and there also appear to penetrate into the subsoil, while on the Modern flood-plain they are found only in pockets or bunches in the surface soil near the outcrops of the quartz or along the river bank. These pockets contain much larger quantities of fragments than those on the upper plain, but are more compacted, and hence occupy less space. The evidence, fragmentary although it is, suggests that the age of the quartz distribution on the flood-plain is not the same as that on the Glacial terrace.

The very wide distribution of small quartz fragments on the sand plain may suggest that they are not of artificial origin. I have looked into this question somewhat closely, and have concluded that to no other agency than human can be attributed their transportation to their present positions. They occur usually in a fine-grained, sandy soil, almost free from pebbles of any kind. Several small "pockets" of undoubted flake-like forms were found in a black muck about one and a half miles west of the Mississippi river. It is difficult to see why the Indians should have brought this useless material into a marshy jungle, but it is equally as difficult to explain its transportation by water, wind or animals. Furthermore, the increase in relative abundance of flakes in approaching known outcrops of the quartz veins in the schist ledges, indicates a derivation of the scattered fragments from them. But at the time the sand-plain formed the river-bed the quartz outcrops were deeply buried, and hence the distribution of the quartz cannot be attributed to water.

On the farm of Mr. Harry Blanchard, several miles north of the Little Two rivers, there is a fine exposure of white quartz in the schist ledges at the foot of a high bank. The top of this bank, which is the edge of the sand-plain, has nearby an occasional small pocket of quartz fragments. Along the "river road," north of the Little Two rivers, an especially developed pocket of flakes and other fragments of white quartz was noted on the sand-plain near a known outcrop of schist. They are here so abundant in the road-side that many scores were in view at one time.

A few flakes were noticed in the road-bed on the sand-plain between the Little and the main Two rivers, but when the latter stream was crossed they totally disappeared. Between here and St. Cloud, although the road continues nearly the entire distance on the Glacial sand-plain, often passing close to the river bank, not a single specimen of angular quartz was found. Searches sufficiently thorough to have brought to light hundreds of fragments anywhere in the country between the Two rivers and Little Falls were frequently made, but not a single specimen was discovered. The singularity of this circumstance disappears when we learn that the quartz-veined staurolitic schist and slate of the Morrison county rock outcrops do not appear in the country southward from the Two rivers, and therefore it is but natural to expect that the quartz fragments derived from them should also be absent in that region.

A visit was made to the "notch," the site of Miss Babbitt's most important discoveries. It has changed much in recent years, and no longer constitutes a satisfactory field of research. In its present condition it is a ravine about 125 feet in length (the upper or eastern end of the original ravine has been filled up with brush and dirt), thirty feet in average width and fourteen feet from the top of the bank to the present water-level. It is cut into the level sand-plain which extends from the moraine hills on the east of the valley to the river. The south side of the ravine has a slope of about 50 degrees, and is covered with grass and underbrush. The north side is very irregular, but has a slope of 40 to 50 degrees. It shows signs of having been greatly disturbed in recent years, probably by Dr. Holmes' workmen in digging a ditch in 1892. No ditch is visible at present, as its banks have crumbled away. The bottom of the ravine is submerged and covered with logs. The north bank exposes fine gravel and sand, but not in definite stratification. The view from the bank would suggest that the immediate walls of the ravine are a talus of incoherent material at least several feet in thickness and covering completely the outcropping edges of the undisturbed strata.

There were several small white quartz chips in the upper few feet of the strata, notably immediately under the soil. One fine quartz flake was picked up on the surface of the field nearby, fifteen feet north of the edge of the ravine. There was a small pocket close to the surface of the bank, but the flakes are in comparatively small number in this locality, many spots along the roads in Swan township, on the west side of the river below Little Falls, much exceeding them. The quartz chips are very sparsely distributed over the sand-plain from the "notch" north and east, but I found a dozen or more angular pieces of white quartz in coarse sand in a gutter in the west end of a hollow near the base of Hole-in-the-day's bluff. They are apparently flakes. All those which have been mentioned were distinctly superficial in position, being confined strictly to the upper few feet and mostly to the upper six inches of the sand-bed. Miss Babbitt's so-called flint implements were of a different class, coming from a thin stratum near the base of the bank. As Dr. Holmes' efforts have demonstrated* that the early claims of their Glacial age were founded on imperfect evidence and were erroneous, I desire to express what I conceive to be the most probable explanation of the phenomena displayed.

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*Am. Geol., vol. XI, p. 219, 1893.

When implements or other artificially fractured rock-masses are found on the sloping sides of ravines or the banks of streams which flow through sandy plains, as in central Minnesota, it is safe to say that they constitute not the least evidence of the occurrence of similar forms in the undisturbed strata, except in the extreme upper portion. The formation of a perpendicular bank in the loosely compacted sand and fine gravel of the Minnesota Glacial flood-plain deposits is practically an impossibility. Just above the old mill on the west side of the Little Falls and St. Cloud road, the Swan river is now engaged in cutting a cove into the 27-foot bank of modified drift. The excavation is so fresh that vegetation has not secured a foothold on the slope. Undisturbed strata outcrop at the top of the section, but below the edges of the layers in place are hidden by an extensive talus of coarse sand and fine gravel. This section is significant as showing that even during a period of active erosion a talus will obscure the edges of the strata. As the talus is removed by the action of the stream at the base, it is being constantly renewed by the breaking down of the strata above.

At the "notch," in view of Miss Babbitt's explicit statement that the implements occurred in a definite stratum which outcropped at the foot of the bank on each side and the upper end of the ravine, we cannot refer them to ordinary talus transportation from the upper stratum of the plain. It is probable that soon after the main excavation of the ravine, and before its sides had fallen down very much, it was the site of a landing-place and rough workshop of the aborigines. Here they brought the quartz which they had quarried from the veins in the rapids, and fashioned it into the rough outlines of the implements which were finished at the village. In the course of time a great quantity of refuse had collected on the flat floor of the ravine, extending as a uniform sheet to the foot of the sloping walls. During the long time which has intervened between then and now, the loose gravel and sand have worked down the sides of the ravine until they reached a slope of comparative stability. In this way, a portion of a quartz-bearing stratum, perhaps a foot or more in width, came to be covered by the talus deposit. Subsequently, further erosion of the floor of the ravine removed the implement(?)-bearing stratum from its central portions, but left it around the edges to outcrop in practically the condition in which Miss Babbitt found it. On this theory we can easily reconcile Miss Babbitt's descriptions with the result of Dr. Holmes' researches. Indeed, if her very definite statement be absolutely correct, as I believe it is, I can conceive of no other explanation of the occurrence of a distinct quartz-chip-bearing stratum on the side of a ravine which cannot expose any of the original undisturbed strata. This would place the age of the so-called implements later than the Glacial period, but yet quite ancient as compared with the present.

I now wish to express, in a general way, the impressions which were received in the examination of the evidence studied in my recent visit to central Minnesota: As others have pointed out, all the quartz chips of artificial origin, which are found in this region, were manufactured during the time that the quartz veins were exposed, namely, while the Mississippi flowed at nearly or quite its present level. These quartz outcrops could be reached soon after the ice-sheet had disappeared from the immediate vicinity, but before the formation of the gravel and sand plain had proceeded far most of them were covered not only by the stream, but also by its deposits. While the upper five feet of the Glacial flood-plain was under formation, not one of the quartz veins in this county was above the stream-bed. Hence, as practically all of the flakes and other quartz fragments discovered by Prof. Winchell, Dr. Holmes and myself come from the upper few feet of the glacial sand-plain, or from a much later flood-plain deposit, they must be of post-Glacial age. In the early part of the present period, when the trenching of the sand-plain to the present river-level had been completed, the quartz veins were again uncovered and the aborigines resorted to them for material to be used in fabricating their implements. So far the theory is absolutely safe; but I am now going on to somewhat unstable ground. After the uncovering of the quartz in place, but before the formation of the Modern flood-plain, the widely-distributed chips on the higher terrace or Glacial sand-plain reached their present position. As we should naturally expect, they are most abundant in the near vicinity of the outcrops, but it is a very puzzling feature of their distribution that they are so uniformly scattered over a broad area, often several miles distant from the river. Subsequently, when the Modern flood-plain formed a lower terrace near the main outcrops, a later race made on it a newer and characteristically different distribution of quartz fragments. This is more local in nature, and undoubtedly quite modern in age. It is probably the work of the Indian tribe which occupied the region just previous to the arrival of the white man. To the former period of activity I would refer the quartz implements (?) found by Miss Babbitt, and also the chips found in the upper stratum at the same locality.

The question of how the fragments of quartz may have been introduced into the subsoil of the glacial sand-plain, often to depths of several feet, is answered as follows: At various places on the higher terrace, notably in the vicinity of Pike rapids, the surface is studded over with a great number of small elongated hillocks, with a slight depression on one side of them. Some of these depressions are still occupied by the semi-decayed stumps of large trees. The fact is commonly recognized by the neighboring settlers that these peculiar hillocks and associated depressions are the sites of trees which have in the past been overthrown by the wind. On moraine hills along the Mississippi river above Brainerd, the same class of slight elevations and depressions was very prominent, and they are quite numerous. Indeed, they are not at all uncommon in this portion of the state. Heavy storms have, during the past 2,000 years, perhaps overthrown the timber on every acre in this district. As Dr. Holmes and others have demonstrated, such a general disturbance of the soil could not help but introduce quartz chips to a depth of say two feet, and occasionally three feet, but never as much as five feet. The decay of tap roots of large trees might be responsible for some chips found at a greater depth than three feet, but such cases would be rare. My experience has been that practically all the quartz fragments which have been introduced from the surface are now found within two feet of it, except that they are scattered in the talus material on slopes.

Before closing these desultory remarks on the quartz fragments in Morrison county, Minnesota, I desire to emphasize the fact that anything like a finished implement is exceedingly rare, even in the large "pockets" of chips on the Modern flood-plain close to the outcropping quartz veins. During my researches I did not find a single piece of quartz showing the least trace of any definite form such as might indicate the nature of the implement which it was proposed to fashion from it. Nearly all the fragments were small and evidently mere refuse, not of the finishing shop, but of the first manipulation of the rock after it left the "quarries." Some, indeed, appeared to show evidence of the marginal secondary chipping, but they were mere flakes, and the evidence probably deceptive. In a few cases forms were observed which might, by a stretch of the imagination, be conceived of as belonging to a palæolithic type, but they occurred as parts of the ordinary refuse, and were mere accidents of manufacture.

Dec. 19, 1896, Freeport, Illinois.

ON STRATIFICATION PLANES.

By Charles R. Keyes, Des Moines, Iowa.

The layered structure of sedimentary rocks has long been regarded as their most characteristic feature. To the surfaces along which splitting is most apparent, the term bedding planes is generally applied. In the treatises on stratigraphy the layered arrangement in rock masses is considered altogether from the standpoint of a purely structural character. Bedding planes are dismissed as only very local phenomena. The text-books on geology seldom give hint of any possibility of bedding planes not having the same stratigraphical value. Statements regarding the laminated characters of the rock usually distinguish only those kinds that are liable to be mistaken for those resulting from causes other than sedimentation.

That stratification planes may have quite different values in geological work, and that they actually do often have a variable significance is manifest from even the casual perusal of most published works relating to stratigraphy, notwithstanding formal statement is wanting.

The phenomenon of bedding, or stratification, belongs to the class of original rock structures, in contradistinction to structures acquired. It results from transportation and deposition of rock particles derived from other disintegrated rocks. In the operation of the gradational processes three distinct phases are represented, according as the agency is wind, ice, or water. Of these, the hydric effects are by far the most important. To these are due nearly all the phenomena connected with stratification structures.

The truly stratified structure in rocks has for its fundamental proposition the doctrine that all materials that are derived from the wasting of the land areas of the globe finally find their way into the sea, there to be laid down in new formations. Deposits formed in lakes and along rivers are also often stratified, but their existence is usually only temporary. Such sediments are also sooner or later swept into the sea. All the sedimentary rock masses, except a few of the more recent, are thus considered as of maritime origin.

When the finer rock materials from the degraded land areas are carried into the quiet waters of the sea they are soon thrown down roughly according to their size and weight. But as the sea floor is constantly rising and sinking, and as the shore is continually retreating and advancing, homogeneous accumulations of any great extent are not possible. The minute changes in the conditions of deposition give rise to lamination in the strata and to the bedded structures, and the greater changes to the alternation of beds.

Local stratigraphic relationship is usually more or less disguised by rock displacement. Since the stratified character of the sedimentary rocks is imparted as the rock mass is formed, it is regarded as an original structure, and the layers and the stratification planes are presumed to be at first disposed nearly horizontally. The stratified rocks have thus furnished our most ready means of determining the succession of the events that a given district has passed through. The subsequent or acquired structures, as flexures and dislocations, can also thus be distinguished and measured. In the case of the massive crystallines, such phenomena can rarely be determined. With the schistose rocks, the various disturbances have been repeated so often that, except in a few instances, the stratigraphic succession can not be deciphered. Important, then, as the stratified structure manifestly is, it would appear that some formal differentiation of its various phases could be advantageously made.

It seems hardly necessary in this connection to note several other layered structures exhibited by rock masses that are not to be referred to stratification. These are acquired structures. They are shown as foliation in the slates and schistose rocks; as lamination produced by shearing along fault lines and thrust planes; and as flowage banding in lavas that have moved in cooling.

Although the planes separating rock beds are so infrequently considered any more than ordinary bedding phenomena, they are on that account none the less real. They not only have a wide theoretical interest, but they have an eminently practical bearing in geological classification. Each kind also has a distinct value in all problems of correlating rock exposures separated more or less widely geographically and in deciphering geological structures.

For purposes of geological correlation and classification there are, among stratigraphic planes, at least four particularly useful distinctions that may be recognized. They correspond in a measure to the planes of division between the main groupings of strata that are considered in geological classification. These stratigraphic planes may be classed as (1) Ordinary bedding planes, (2) formational or terranal planes, (3) great planes of sedimentation and serial planes, and (4) erosion or unconformity planes.

Bedding Planes, as here restricted in meaning, refer to the minuter layered characters of the sedimentary strata. They are the laminations in the shales, and the cross-bedding and ordinary bedded structures in sandstones and limestones. The layers that the term embraces, vary from the merest films to thick massive plates. Bedding planes being quite local in their nature are of little or no importance in the broader geological considerations.

Terranal Planes may not always be distinguishable at first glance from bedding planes, and locally may coincide with them. In the field, when a number of exposures are compared, or an outcrop traced for any considerable distance, the planes separating the terranes, formations or geological units, and indicated in mapping or selected for special recognition, are usually readily made out on account of a more or less abrupt change in the lithological characters of the contiguous rock masses.

These formational planes may be regarded as conforming to huge warped surfaces. They follow the upper or lower faces of the irregularly lenticular rock masses constituting the geological units. In cross-section, they form broadly curved lines. They are significant of very marked changes in the physical conditions of the region at the time the deposits were laid down. These changes may have been produced by diverse agencies, the exact nature of which is, in the present connection, immaterial. These planes approach and emerge into one another, regardless of any observable law, though there is no doubt some close interdependence between them and the contemporaneous drainage lines of the neighboring shores.

Seen usually only in cross-section, as a mere line between terranes, the formational plane has heretofore received no more attention than the ordinary local bedding plane. Since, however, of recent years the "formation" or terrane has come to be recognized as the primary geological unit for all classification of rock-masses, and for mapping, the planes bounding these units assume an importance not heretofore possible to assign to them. They no longer should be looked upon in the same light as simply bedding planes.

Great Planes of Sedimentation are those that separate rock series in the same geological province. They may coincide locally with formational planes and even bedding planes. They may be well defined in one part of a province and in another part pass through the very middle of a rock succession that is apparently homogeneous and unbroken in all lithological, faunal and other characteristics. The real nature of these planes usually comes out only after the geology of the region has been carefully worked out.

A concrete example, in a limited province, is a coal horizon, whether yielding mineral fuel or not. Also, a limestone, that in the direction of an ancient shore passes insensibly into shale and then into sandstone, may have one of its faces on the horizon marking the line of division between two great rock series.

In the area towards the sea the two series may be clearly separable, while among the shore deposits no such division plane might be suggested. Moreover, it might there remain long unnoticed were not the great plane traced directly from the limestone district.

Again, an erosion plane may often coincide with a great plane of sedimentation, representing as it does a hiatus in local deposition. Whenever it occurs an episode or chapter in the local or regional physical history is missing. The erosion plane often stands for a time of base-leveling, when heavy deposits for the formation of limestones are laid down very near shore. When the land sinks again, the calcareous succession remains unbroken. Yet, a new cycle of sedimentation is inaugurated. The unconformity plane projected seaward through the limestone succession is still a horizon in the latter that is one of the most natural ones in the classification of provincial deposits.

Erosion Planes, as already intimated, have a special significance. They are more or less uneven, and indicate a stratigraphic break. At such a horizon, an entirely new cycle of deposition begins, the faunal succession is broken, and the rock sequence above bears no relation to that below. The extent of the erosion plane varies widely in different cases. It may be very local, covering only a few hundred square miles, or it may stretch out over the greater part of a continent, crossing from one geological province to another without interruption.

The erosion plane is, in stratigraphy, called an unconformity; and as a phenomenon of unusual significance by itself, may be further considered. Its importance as a means of primary geological classification is given at length elsewhere.

While in the unconformable relations of two sets of rock layers a stratigraphic hiatus is generally recognized, the phenomenon is usually looked upon more as a mere structural feature, than as representing a momentous event in the physical history of the region. The term as most rightly applied refers to a stratigraphic break caused by an erosion interval. So far as the structural relations of the strata are concerned, two very distinct kinds are recognized. In the one the stratification or bedding planes are essentially parallel and in the other they make a considerable angle with each other. These are, however, only special cases of the general problem.

Unconformities represent, for the region in which they occur, epochs or periods during which erosion, instead of deposition, has taken place. They may be very local in extent, but usually they indicate the existence of conditions that are widespread. The fact that the lower set of beds is more or less tilted and their upturned edges worn off implies a considerable elapse of time. Mountains may have been formed and removed in the interval between the formation of the two sets of rocks.

As a rule the discordance in dip is not the only notable difference between the sequence above and below the plane of unconformity. Besides being merely tilted, the beds below are often folded, metamorphosed and perhaps intersected by eruptive masses.

The unconformity planes, inconspicuous and as difficult to trace as they are, have, then, an importance that has rarely been appreciated to the extent that it really deserves. They indicate, as it were, halting places that enable geological history to be subdivided and the rock formations to be classified in the same way that great national catastrophes mark epochs in human history.

Unconformities are generally considered as local phenomena. This idea does not always take into consideration the real nature of the facts. Very marked discordance is liable to be confined to limited belts. The minor features of unconformities are far more extensive. As Van Hise has remarked, an orogenic movement may relieve itself along a comparatively narrow belt, that as a result of differential uplift is one of great denudation, while the adjoining plain is little folded and little eroded. The stratification of the new series would nearly coincide with those of the older in the plain, but the two would meet at high angles in the disturbed belt.

To recapitulate, it would appear that:

1. The so-called bedding planes usually recognized as characterizing the sedimentary rocks are in reality complex phenomena instead of simple;

2. Bedding planes, so-called, are usefully grouped into several distinct classes according to their historical significance.

3. The variable value of the so-called bedding planes is

not only of great theoretical import, but it has a vast practical bearing in all stratigraphic work.

4. In a simple vertical section it is possible for planes of all four orders to coincide, but laterally in all directions, many of a smaller order may be included in one of the next larger.

ERUPTION OF MAUNA LOA, 1899.

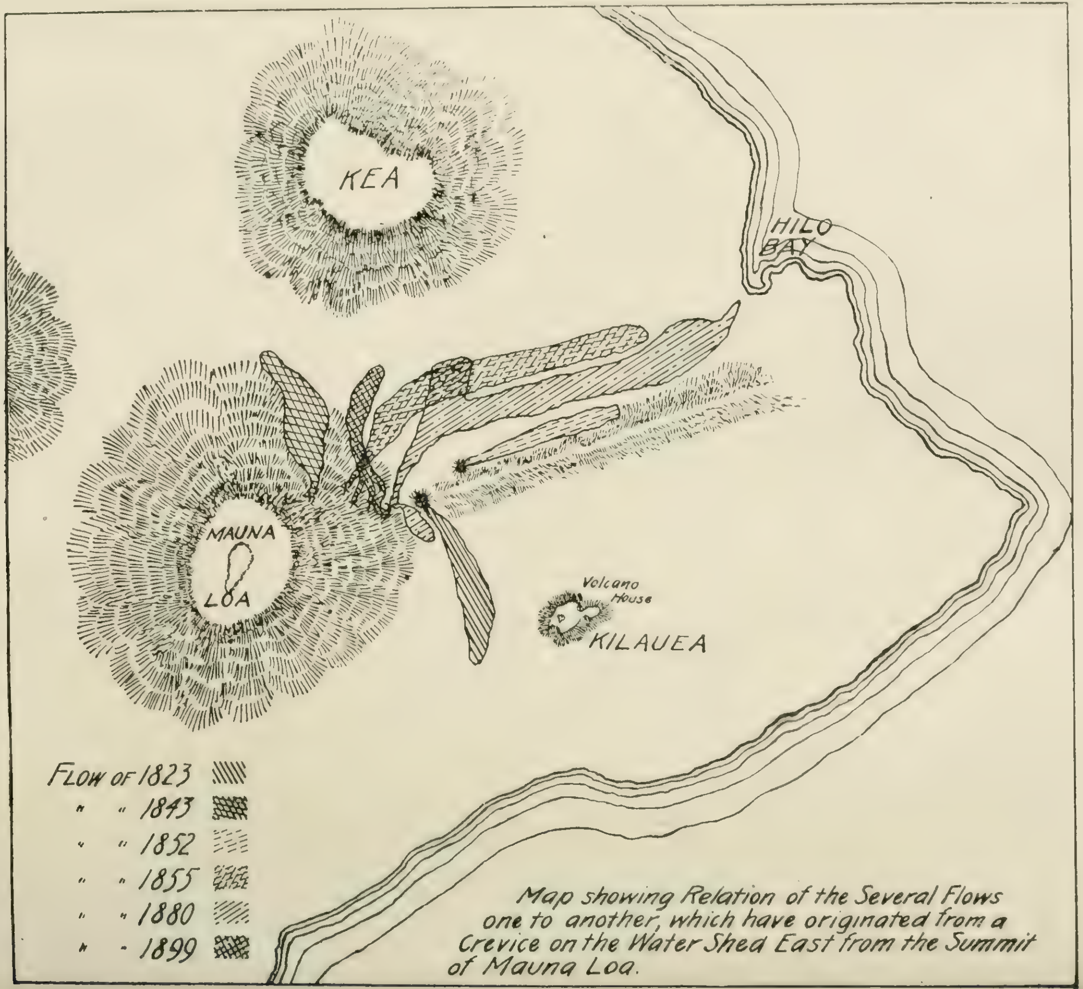
By Edgar Wood, Honolulu.

(Plate XIV.)

On the morning of the 4th of July (1899), news was received that Mauna Loa was in eruption, that light of great brilliancy had been seen in the summit crater, in the very early morning. Later in the day the report was confirmed. The first appearance was about ten minutes past 3 a. m. It seems first to have been seen from Punalun, where a steamer was loading.

From the summit crater, Makuaweowea, a column of light and smoke ascended into the air, to the hight of, perhaps, 20,000 feet, spreading out like a vast umbrella. The people, at Punalun, seem to have noted no violence in the outbreak but, at the Volcano house, at Kilauea, the inmates tell of an explosion of considerable violence. At first the people at the Volcano house looked in the direction of Kilauea where an eruption had been recently expected, but all was quiet there. A different, sight, however, met the eye in turning to Mauna Loa, The clouds, in every direction reflected the fire. Night was turned into day, as the heavens were lighted up with the brilliancy of the burning mountain. An observer, who had witnessed three other eruptions of the same mountain, declared this to be the largest and most brilliant. The reflection was plainly visible many miles at sea.

During all of July 4th, the mountain was covered with clouds. Early in the morning of July 5th, when the clouds lifted, it was seen that the fire had moved, that the light was no longer at the top of the mountain. The lava flow had begun. From the side of Mauna Loa, about 3,000 feet from the top of the mountain, two great fountains of liquid fire threw high into the air immense quantities of seething, glowing lava. The



Map showing Relation of the Several Flows one to another, which have originated from a Crevice on the Water Shed East from the Summit of Mauna Loa.

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source of the flow is near that of the flow of 1880-81. At first it was reported that there were two streams, one flowing down the Kau side of the mountain, the other, and much larger one, going towards Mauna Kea.

As soon as the lava had begun to flow parties were organized to visit the scene of action. The fire fountains were situated as high as 10,800 an 11,000 feet respectively. Different parties took different routes. Leaving the Volcano house, on the morning of July 10th, with a guide, we proceeded up the southeast slope of Mauna Loa, by way of the Koa forest on Shipman's ranche. Emerging from the forest, we soon struck the flow of 1823. Crossing this flow we proceeded directly up the slope towards Red hill, or Pun Waulu. Within a mile of the hill we encamped. We had hoped to camp nearer the fires but night came on. Traveling became difficult and dangerous. The lava, over which we were obliged to go, was full of small cracks and fissures, which made traveling a good deal like going on shell ice. The night was perfectly clear. All around was a wilderness of black lava. Not a shrub or trace of vegetation was anywhere in sight. The bare surface of the lava radiated its heat so rapidly that, as soon as the sun went down, the cold was intense.

At daybreak we prepared to set out again. The view from the camping ground, of the sea and the sunrise was one of rare beauty. We fain would have lingered but were obliged to hurry on as there were several miles yet to be traversed before we would be in a position to command a full view of the lava fountains.

At length we came to the crest of the ridge, up the side of which we had been climbing, and there before us, were the cones spouting liquid fire. All around were small craters or cones from which all signs of fire had departed. Some had long been dead. Others gave evidence of having been active more recently. The country in the vicinity of these cones was strewn with fresh lava. There were two principal live cones, one much more active than the other. Great masses of rock at a white heat were being hurled high into the air. These were probably pieces of the crater wall. Sometimes quantities of molten lava were blown out. At other times a mixed material in which there was a gread deal of sulphur. This molten matter would sometimes be thrown to the hight of 200 feet. Almost continuously it went higher than one hundred feet. This process was going on with almost no interruption, while, at intervals, great volumes of smoke poured forth from the edges of the crater. The principal cone was about 150 feet high on the North side. The other sides were considerably lower. A deep crack between 30 and 40 feet wide ran off in an easterly direction. The cone itself was nearly, if not altogether, 200 feet across the top, filled with lava at a white heat, never still, ever leaping sometimes higher, sometimes lower, ever falling back upon itself or spilling in flakes over the side of the cone. Explosions were numerous almost continuous, while all the time, the rushing roaring sound of the fire fountains filled the air.

Wonderful as was this sight, the view of the river of fire was not less so. It rushed through the opening at the speed of a race-horse, and, plunging over a fall of perhaps fifteen or twenty feet, went madly through a deep channel down the side of the mountain. It rushed along with such force that the surface was marked with undulations like the waves of the sea.

An engineer, connected with one of the exploring parties, estimated that the channel was fifty feet wide, that the flowing lava was ten feet deep, and that its velocity was forty feet to the second. Sometimes the flow would seem to lessen but ever after such lulls it would come forth as strong and as fiercely flowing as before.

This cone, the lower one, is about a mile above the principal cone of the flow of 1881. The other is nearly five miles further up, nearer the summit of the mountain. It will be remembered that, in the flow of 1881, the cones from which the lava came were situated on a fissure which followed the course of a "divide." In the recent flow the lava came from cones which were situated on the Kea side of this "divide". From these cones came two main flows, which, joining presently, crossed the flow of 1855 and ran down the slope between the 1855 flow and that of 1843.

Several smaller streams following depressions along the ridge were either lost or, meeting with an obstacle, were turned down the slope uniting with the main flow. One of these streams, being turned aside, flowed around the Kau side of the principal cone of 1881, giving rise to the impression that a flow was going off in that direction. This stream, however, was only following a depression and was soon lost.

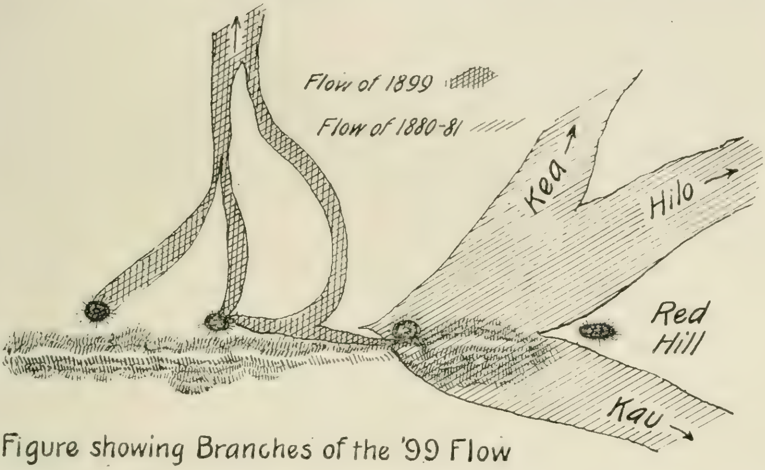

Figure showing Branches of the '99 Flow and its Relations to the Flow of 1880-81.

Position of the flow of 1899.

The main flow which was almost altogether aa, stopped on the tableland between Mauna Loa and Mauna Kea on July 26, having a length of from twelve to fifteen miles and an estimated width, along its lower course of about a mile.

Mauna Loa's eruption was preceded by an earthquake shock on June 11th. While the volcano was active two more, of considerable violence, were felt on the Island of Hawaii. For some days, during which a south wind blew, while the volcano was in eruption, Honolulu, on Oahu, two hundred miles distant, was covered with a great smoke cloud. Many of the citizens declared that there was a distinctly sulphurous smell to the smoke, while a gentleman, relates that, during a ride in the mountains in the vicinity of Honolulu, he had been distinctly struck in the face by particles of falling ashes or grit. The ocean liner, "Mariposa," struck the smoke while 600 miles off to the northeast on the 17th of July. About the same time the "Morning Star," coming from the southwest, was met by the smoke. The officers on board these ships were not able, for two days, to take observations on account of the sun being obscured by the smoke.

On the 24th of August, a month after the lava had ceased flowing, fire was again seen on one of the cones. It was hardly more than a momentary flash however. The same thing was observed on the top of Mauna Loa two days before the eruptions. Light appeared at the top of the mountain, disappearing in a few seconds. During the eruption, the summit of Mauna Loa was frequently covered with a light colored cloud. It is reported that this condition prevailed both before and after the time of eruption.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

A Memoir on the Paleozoic Reticulate Sponges constituting the Family Dictyospongidæ. By JAMES HALL in collaboration with JOHN M. CLARKE (University of the State of New York, Albany, 1899. 344 pages, 70 lithograph plates, large 4to.)

This volume is the final execution of a plan conceived by the late professor Hall to bring together in monograph form all obtainable facts pertaining to these ancient glass sponges for which he, many years ago, proposed the family name here used. The work is of especial interest as demonstrating the abundance, variability and biologic importance attaching to what has been heretofore regarded an inconsiderable element of paleozoic faunas. The presence of seventy species of these organisms in the Chemung fauna of New York and Pennsylvania may startle students who have collected assiduously from these sea bottoms, perhaps without finding a trace of any. At that time, however, and during the deposition of the calcareous shales of the Keokuk group at Crawfordsville, Indiana, the glass sponges seem to have culminated. There were veritable sponge "plantations" in these early seas, and the authors have located several of these in the Chemung sediments, from some of which several hundred specimens of a given species have been taken. It is seldom that these plantations produce more than a single species, and in some cases the species seem to be restricted, each to its peculiar colony. The memoir opens with an introductory chapter treating of the general nature of the sponges, with especial reference to the silicious sponges, and in particular to the Hexactinellida, the order to which the Dictyosponges appertain. Following chapters are devoted to the spicular skeleton of the Dictyosponges, general morphology, habitat, their bibliography, classification, etc.

The descriptive part of the work embraces 128 species under 29 genera. This chapter is illustrated with text cuts showing the spicular structure, in addition to the numerous lithographic plates.

Petrographical Notes on Some Rocks from the Fiji Islands. By ARTHUR S. EAKLE. (Proc. Amer. Acad. Arts and Sci., vol. 34, no. 21, pp. 581-595, May, 1899.)

The rocks here described were collected by Mr. Alexander Agassiz during the winter of 1897-98. The Fiji group consists of two larger islands—Viti Levu or Great Fiji, and Vanua Levu—and a large number of smaller islands. The first mentioned and largest of the islands differs from the others, as far as known, in having plutonic rocks, as granites, syenytes, diorytes and gabbros, while the other islands, aside from their coral rocks, show surface igneous rocks. A specimen of dioritic granite is described from this largest island, Viti Levu, and the other specimens are andesytes (of several varieties) and basalts. In all some twenty-five islands are represented by the specimens collected, and a description of the characters of each specimen is given. U. S. G.

Mineral Resources of Kansas, 1898. By ERASMUS HAWORTH. (The University Geological Survey of Kansas, Annual Bulletin on Mineral Resources; 127 pp., 21 pls.; Lawrence, July, 1899.)

The total mineral products from Kansas for 1898 amount to nearly $27,000,000. Of this the non-metallic products, coal being by far the most important, give a total of about $6,000,000. The only metallic products are lead and zinc, over $4,000,000 worth of these two metals being produced. The smelting products amount to over $16,000,000.

Twenty-four tables show the amounts of the different substances produced, both by counties and by districts, and in some cases by geological formations. A number of reports of gold and silver in Kansas have been made, but these are not substantiated. As a final report on lead and zinc will be completed during the next fiscal year, the information presented concerning these subjects is briefer than would otherwise be the case. Nearly ninety-five per cent. of the coal comes from the Lower Coal Measures, and the balance, except about 500 tons from the Cretaceous, is from the Upper Coal Measures. In certain years the amount of Cretaceous coal produced has been greater, as in 1894, when over 17,000 tons were produced. The few pages devoted to the geology of the oil and gas fields are quite acceptable, as information concerning this subject in Kansas is difficult to obtain. Under the heading of salt Mr. M. Z. Kirk contributes two papers, one on "Kansas Salt" and one on "Technology of Salt," and Dr. Haworth describes the "Geology of Kansas Salts," including the records of a number of salt wells. U. S. G.

Geschichte der Geologie und Paleontologie. By K. A. VON ZITTEL. This work of over 850 pages, published under the auspices of the Bavarian Academy of Sciences, ranks as one of the most important geological contributions of the year, and is certainly the most comprehensive account of the progress of geology and paleontology that has been written. In so saying we do not overlook the fascinating sketches of Lyell and Geikie, nor the numerous compendiums of geological literature. The field here covered is a broader one, and is treated in a masterly way.

The development of the science is traced from its crude awakening amongst the ancients up to the end of the nineteenth century. About one-third of the book is devoted to the period prior to 1790. The next thirty years, during which the foundations of modern geology were laid through the influence of Werner and his school, and of paleontology through the labors of William Smith, Cuvier and others, is designated as the "heroic age" of the science. To the modern era, dating from 1820, seven lengthy chapters are devoted, under the captions of cosmic, physiographic, dynamic, topographic and stratigraphic geology, with one each on petrography and paleontology. The important influence of universities, geological societies, and government surveys in promoting the science is discussed at length, this chapter being an expansion of previous articles on the same subject, one of which appeared in The Geologist for September, 1894.

Although the biographic side is kept subordinate to the main issue, not a little is related of the personal characteristics of former great lights in geology, and numerous footnotes interspersed here and there furnish condensed narratives of their lives, reference to which is facilitated by a copious index.

Critical and in the main impartial accounts are given of the more important theories and investigations which have determined the course of geology and paleontology. The development of topographic geology is traced according to the different countries which have fostered it, that of stratigraphic geology is treated according to the several geological periods, and that of paleontology according to the various groups of the animal kingdom. This arrangement fills in abundant details which are wanting or barely outlined in the chronological method employed by Marsh in his address on the "History and Methods of Paleontological Discovery" (A. A. A. S. 1879). Commenting on the tendencies of the modern school of paleontology, which lays great stress on individual growth-stages, the author finds it difficult to repress a hint of his personal bias, especially under the head of Mollusca, Trilobites, etc. On the other hand rich tribute is paid to the genius of Leidy, Cope, Marsh and others who have fostered the Darwinian hypothesis. Numerous literature-references are appended at the conclusion of each chapter, directing the reader to the original sources of information. A work of this kind cannot fail to receive everywhere a most cordial welcome. C. R. E.

Geology of the Aspen Mining District, Colorado. By JOSIAH EDWARD SPURR. (U. S. Geol. Sur. Mon. XXXI, xxxiii and 260 pp., 43 pls., and atlas. Washington, 1898).

The Aspen mining district presents, in addition to its great economic importance, an interest that is unusual from a purely scientific standpoint. The scope of the report is summed up as follows: Chapter I treats of the geological formations both sedimentary and igneous, their original structure and the conditions under which they were laid down or intruded; Chapter II considers the physical changes which have come about since their deposition and consolidation, consisting mainly of folding and faulting; Chapter III gives full descriptions of the mines and the productive localities; Chapter IV discusses rather fully the chemical changes which came about subsequent to or were attendant upon the physical changes, and were produced chiefly by metasomatic change, dolomization, silicification, ore deposition, and other phenomena; Chapter V is a short sketch of some of the surface changes which have occurred in comparatively recent times, since ore deposition. An introductory chapter is by S. F. Emmons.

The general geological features are thus tersely stated: "The fundamental rock in the Aspen district is a granite, with occasional gneissic structure. Above this come successively the sedimentary beds of the Cambrian, Silurian, Devonian, Carboniferous, Juratrias and Cretaceous. The beds of the Cambrian, Silurian and Devonian are comparatively thin, while the Carboniferous, which is divided into three distinct formations -the Leadville, the Weber and the Maroon–attains a great thickness. The Juratrias and the Cretaceous are also very thick, the latter containing the various subdivisions of the Dakota, the Colorado, the Montana and the Laramie. Separating these different beds at intervals are various unconformities and planes of erosion, which help one to read the history of the rock and to understand the conditions under which the beds were laid down."

In Cretaceous time probably were intruded the igneous masses. After this came dynamic disturbances giving rise to the principal mountains of the district. At first profound faulting occurred. From that time to the present day faulting has gone on. The result has been to produce a remarkable series of fractures, many crossing one another. It is noteworthy that the slipping is still going on in a measureable degree. Bench-marks of the engineers have moved several feet in the course of a decade. The timbered mine entries originally nearly rectangular in shape, are, in a short space of one or two years, made very decidedly rhomboidal in cross-sections—so much so that the car tracks have to be laid on short ties which are from time to time moved laterally until finally they abut the side of the entry. The upper portion of many shafts has moved entirely across the lower portion, in some cases shutting off the latter completely; in others the two ends are connected by a short incline.

The discussion of the ores and their deposition are of exceptional interest. They are regarded as precipitated from heated waters that have come up along the fault planes. Near the surface the ores are in the form of oxides, sulphates and carbonates with some sulphides. Downward these soon give place to the pure sulphides. Silver-bearing galena is the most important ore, blende, pyrite, polybasite, tetrahedrite and tennantite also are abundant. Small quantities of arsenic, cadmium, cobalt and nickel are present. The paragenesis of the vein materials is of special significance.

The deposition of ore is found to be coextensive with the faulted district. Where the fractures fade out into unbroken strata the ores disappear. The vertical extent of the ore bodies is unknown. Present mining operations give a vertical range of over 3,500 feet between points where the ore is continuous.

The chapter on glacial action in the region presents some features that deserve more than passing mention. "The evidence goes to show that at a relatively remote period the Aspen district was covered by a great ice sheet, which moved west, away from the Sawatch range, over hill and valley. This glacier carved the surface into typical glaciated, rounded and drumlinoid forms, and excavated the softer shales and sandstones more than the resistant granite. The debris of this glacier is found on top of the highest mountains of the district. Subsequently this ice sheet shrank into separate glaciers, which followed the valleys of pre-existing streams and in large measure carved them into their present forms. These valley glaciers, by erosion along their sides, caused a steepening of the mountain slopes, and so brought about the removal of most of the previously accumulated drift. It thus happens that at present the sides of the mountains often appear bare and unglaciated, and the drift of the earlier glaciation is found only on the summit. At a still later stage in the glaciation the valley of Roaring Fork, was occupied by a long, narrow glacial lake, which probably resulted from some temporary dam. During most of its existence the surface of this lake was 400 or 500 feet above the present town of Aspen, and into it the dying glaciers of Hunter creek and its water emptied." An appendix on the Measurement of Faults contains some distinctions to be recognized with advantage. Altogether the geology of the Aspen district is a notable contribution to our knowledge of the ores and geology of Colorado. It is clear, terse, and easy to understand. If more of our accounts of important mining districts were modeled on the same plan our knowledge of ore deposits in general would be in a far more satisfactory condition. C. R. K.

The Crystal Falls Iron-bearing District of Michigan by J. M. CLEMENTS and H. L. SMYTH; *with a chapter on the Sturgeon River Tongue*, by W. S. BAYLEY, *with an Introduction* by C. R. VAN HISE. (U. S. Geol. Survey, 19th Ann. Rept., pt. 3, pp. 1-151, pls. 1-11, 1899.)

The Crystal Falls district is in the northern peninsula of Michigan, immediately adjacent to Wisconsin. This district, as far as its present development is concerned, is not of the economic importance of either the Marquette iron-bearing district to the northeast nor the Menominee district to the southeast. It is nevertheless of much interest from an economic as well as from a geological standpoint, for in it are in general the same iron-bearing formations as in the two adjacent mining districts, and a study of this intervening area (the Crystal Falls) makes it possible to correlate the strata in the two important districts. The equivalence of the rocks of these three districts can now be established with a considerable degree of certainty, although the sequence in each district is not precisely the same as in the others. In general in each district the Lower Huronian is represented by a lower quartzite overlain by a dolomite and this in turn overlain by an iron-bearing member which forms the upper part of the Lower Huronian. The sequence in the Upper Huronian has not been so fully worked out, but this formation is present in each of the three districts.

Heretofore comparatively little concerning the geology of the Crystal Falls district has been known, owing to infrequency of exposures and its unimportance as a mining district when compared with the adjacent Marquette and Menominee districts. The present paper, which is an abstract of a monograph (No. XXXVI. of the Monographs of the U. S. Geological Survey), gives in condensed form an excellent description of the geology of the district. On the east of the Crystal Falls area is a large mass of Archean rocks, largely granitic in character and at times schistose. To the west of this large mass are two smaller masses of Archean, oval in shape and about ten miles long (north and south) by two or three wide. Resting unconformably upon the Archean and with the uncomformity sometimes much obscured by metamorphism, are the Lower Huronian rocks which in ascending order are as follows: Sturgeon quartzite, Randville dolomite, Mansfield (slate and schist) formation, Hemlock (volcanic) formation, and Groveland (ferruginous) formation. Unconformable above the Lower Huronian is an unknown thickness of undivided Upper Huronian rocks consisting essentially of conglomerates, quartzites, graywackes, several varieties of slate, and ferruginous rocks. Of later date than all the foregoing are considerable masses of igneous rocks, which are of a basic nature—diabases, gabbros and diorites. These are probably of Keweenawan age. Overlying all are remnants of horizontal Cambrian sandstone.

At the end of Lower Huronian time the region was subjected to folding and again at the end of Upper Huronian time, the latter folding being in places very intense so that the strata are now not infrequently nearly vertical. The folding and the intrusion of igneous rocks, which took place later than the last folding, induced metamorphism which varies much throughout the district. Two interesting features of this metamorphism may be mentioned. One is the production of a conglomerate-gneiss, the matrix of which has been completely recrystallized, but which still contains numerous flattened pebbles and boulders. The other is the production, from some of the Hemlock volcanic rocks, of completely crystalline schists which now show no remnant of an igneous texture or structure. The detailed structure of the region cannot be here given, but two very noticeable features are the quaquaversal dips surrounding the ovals of Archean rocks and the synclinal structure between these ovals.

Iron ore, mostly hematite, is known from the Mansfield and Groveland formations of the Lower Huronian and from near the base of the Upper Huronian. The origin of the ore and its concentration at certain points are regarded as in general identical with the origin and concentration of iron ores described by Van Hise from other parts of the Lake Superior region, notably from the Penokee and Marquette districts.* It is, however of interest to note that in this paper Smyth presents facts to show that the iron ore of the Groveland formation in the Felch Mountain range is derived from original glauconite. While he admits that he does not consider this origin as demonstrated here, still he states that in his opinion the iron and silica of the rocks just mentioned were originally present largely in the form of glauconite. This agrees with the work of Spurr, who, a few years ago showed that the iron ores of the Mesabi range had this origin.†

The Hemlock volcanic formation, which immediately succeeded the Randville dolomite in places and which is regarded at certain points as the time equivalent of both the Mansfield and the Groveland formations, has a varied and interesting lithology and is described by Clements. While in the main of volcanic origin there are some interbedded sedimentary rocks, and, in fact, all gradations from pyroclastics to normal sediments occur. This author makes a special point of distinguishing between the eolian volcanic deposits, to which he restricts the term tuff, and the water laid volcanic deposits, which he terms volcanic conglomerates, etc. The igneous rocks of the Hemlock formation are both acid and basic, the former being rhyolite-porphyries and aporhyolite-porphyries and the latter basalts—non-porphyritic, porphyritic and variolitic. Both acid and basic pyroclastics occur. In some of the rhyolite-porphyries the quartz phenocrysts are surrounded by quartz aureoles and the groundmass is frequently micropoikilitic, this author regarding the latter texture as in this case an original one. Many of the basic lavas show an ellipsoidal parting as a result of which surface exposures of the rock resemble a conglomerate with rounded boulders from a few inches to eight feet in diameter. Between these boulders or ellipsoids is a sparse schistose matrix of nearly the same color as the included masses. Such ellipsoidal greenstones are known from other parts of the Lake Superior district, and these here described are very similar to the forms of a volcanic agglomerate described by N. H. Winchell from the Vermilion iron range.‡

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*U. S. Geol. Survey, Monographs XIX. and XXVIII.

†Geol. and Nat. Hist. Survey of Minnesota, Bull. 10, 1894.

‡Amer. Geol., vol. 9, pp. 359-368, 1892. Geol. and Nat. Hist. Survey of Minnesota, Final Rept. vol. 4, p. 255, 1899.

An important element in this report, as in any properly prepared report on a district where mineral wealth probably exists, is the presentation of a geological map, accurate in as far as exposures will allow, which indicates definitely the areas where there is no prospect of finding ore deposits and those in which exploration may be successful. In the Crystal Falls district scarcity of outcrops has rendered this work difficult, but the mapping out of several lines of magnetic attraction where there are practically no exposures has greatly increased the value of this report from an economic point of view. In fact the reviewer understands that certain explorations, made since the field work was completed and made in localities indicated by the authors of this report, have been successful. U. S. G.

Upper Silurian Fauna of the Rio Trombetas, Province of Pará, Brazil. (Archivos do Museu Nacional do Rio de Janeiro, vol. X, 1897-1899, 48 pages, 2 plates), and *Devonian Mollusks from the State of Pará, Brazil.* (Ibid., 125 pages, 5 plates). By JOHN M. CLARKE.

Dr. Clarke expressed several years ago, in a conversation, his disappointment at the fact that two manuscripts of his containing the descriptions of interesting Brazilian faunas had probably been lost in that country. It is highly gratifying that this has not happened; for the papers, after having been comfortably asleep in the drowsy tropical climate for almost eight years, have suddenly become awakened and presented in a handsome volume, bringing with them the information that the copies for distribution may soon arrive. As the papers bear the dates of December 10, 1891, and April 25, 1892, it is obvious that some of the discussions which they contain have been superseded by later publications, a circumstance that is apt to somewhat diminish the author's pleasure at the recovery of these already given-up children.

Both papers are printed in the Portuguese and English languages. The fauna described in the first paper was discovered in yellowish micaceous sandstones on the Trombetas river, a northern tributary of the lower Amazonas, during the existence of the Geological Survey of Brazil, and were placed by Dr. O. A. Derby in Mr. Clarke's hands. The collection contained, besides the fossils from this sandstone, a fucoid from a gray sandy shale from Oiteiro do Cachorro, which proved to be identical with the well-known Arthrophycus harlani Conrad, of the Medina sandstone.

The yellowish sandstones abound in fragments of spicules of hexastinellid sponges and in brachiopods. Among the latter are a Lingula which exhibits the characters of the L. oblata of the Clinton; and a new Lingulops (L. derbyi), represented by a beautifully preserved internal cast of one of the valves, which permits some interesting observations in regard to the structure of this fossil and the development of the Lingulas through Lingulops into the Trimerellidæ. This particular form of Lingulops seems to be most nearly related to the species described from the Hudson River shales. There was further found an Orbiculoidea (O. hartti), which does not show any relation to any of the North American Silurian forms; a Pholidops (Ph. trombetana), the beautifully distinct casts of which abound in the sandstone. Several new forms of Orthis (O. callactis Dalman, var. amazonica, var. nov.; Dalmanella freitana, and D. smithi) came under observation. The first form belongs to the normal group of Orthis, which reaches its typical development in the age of the Niagara and Wenlock periods; the second is very nearly related to the Hudson River form O. emacerata, and the third is similar to O. testudinaria of the Trenton and Hudson River groups. A Chonetes which occurs at the Trombetas is compared by the author with the Waldron-form Ch. nova-scotica. For a most interesting little brachiopod the term Anabaia has been introduced as denoting a sub-genus of Anoplotheca. Subsequently, in the Palæontology of New York, vol. viii, Part ii, the sub-genus has been raised to the rank of a genus, and a short description of the same inserted. While the form is peculiar by its abruptly ending plications on the median fold, its hinge structure shows it to be the precursor of the Devonian genera Leptocoelia and Anoplotheca. Another species of this new genus (A. anticostiana) from the middle Silurian of Anticosti, is also described.

Several new pelecypods were found in the fauna from the Rio Trombetas. Among these are two species of Anodontopsis (A. putilla and A. austrina), the former of which may be compared with Hall's Nucula obliqua from the Hudson River group, while possibly both belong to Barrande's genus Sluzka from the uppermost lower Silurian of Bohemia. Two new Tellinomyas, viz. T. pulchella and T. subrecta, are described. T. pulchella has a remote similarity with T. curta Hall of the Clinton group. Clidophorus brasilianus, sp. n., approaches nearest to C. planulatus Conrad, of the Trenton limestone.

Of gastropods only a Bucaniella, very much like but considerably larger than Conrad's B. trilobata of the Medina and Clinton faunas, and two imperfect casts of a Murchisonia were found.

The Pteropoda are represented by a Tentaculites (T. trombetensis, sp. n.), which finds a near ally in the T. distans of the Clinton group described by professor Hall as a Cornulites), and a small-sized Conularia (C. amazonica), which presents a very close resemblance to Hall's C. niagarensis, especially to the small variety described by Dr. Foerste from the Clinton group of Ohio.

The presence of cephalopods in the fauna of the sandstone is indicated by fragments of an Orthoceras and of a Cyrtoceras; and the crustaceans are represented by Primitia minuta Eichwald (Leperditia [Isochilina] cylindrica Hall, from the Utica and Hudson River groups) and Bollia lata Vanuxem, var. brasiliensis, which shows some minor differences from the common Bollia lata of the Clinton fauna.

The analysis of this fauna verified the opinion expressed by Derby as to the Silurian age of the sandstone of the River Trombetas. It is the oldest fauna yet described from Brazil, and the graptolites recently described from this region by Katzer do not indicate greater age. The most interesting feature of this fauna is that it shows a pretty equal commingling of lower and upper Silurian elements (earlier Silurian: Orthis freitana, O. smithi, Anodontopsis putilla, A. austina, Tellinomya pulchella, T. subrecta, Clidophorus brasiliensis, Primitia minuta; later Silurian: Lingula cf. oblata, Lingulops derbyi, Orthis callactis, var. amazonica, Chonetes cf. nova-scotica, Anabaia paraia (comp. A. anticostiensis), Bucaniella trilobata, var. brasiliensis, Tentaculites, Conularia amazonica, Bollia lata, var. brasiliensis): hence "the inference is quite natural that in this region the break in the record represented by the conventional plane of separation between the upper and lower divisions of the series is obliterated. The fauna is a middle Silurian."

The material described in the second paper was collected in the Devonian strata about the little village of Ereré and along the banks of the rivers Maecuru and Curua, northern confluents of the Amazonas, by an expedition that consisted of Messrs. O. A. Derby, Dr. J. de Freitas and H. H. Smith, and had been sent out by the late professor Ch. Fred Hartt, when director of the Commissao Geologica do Brazil. This expedition visited Ereré, the fauna of which locality had been made known before by Messrs. Hartt and Rathbun, and discovered the remarkable localities on the Maecuru and Curua rivers. The brachiopods collected at these places have been described by Mr. Rathbun (Proc. Boston Soc. Nat. Hist., vol. xx), and the trilobites by Mr. Clarke (Arch. do Mus. Nac., vol. ix), who, by the present publication, has been permitted to bring to public notice all mollusks from the latter localities and the new, or not yet illustrated, forms from Ereré.

The richness of the new localities is proved by the fact that the expedition, though handicapped by the possession of only one canoe, produced 78 species as against 48 species from Ereré, the output of three collecting visits.

It becomes apparent from Derby's description of the geologic relations of the Devonian of the lower Amazonas, that the fossils came from a few beds of white or yellowish sandstone, which have a thickness of thirty feet, and which yield the fossils as beautifully preserved impressions.

The analysis of the Brachiopoda by Mr. Rathbun brought out the fact that the fauna of the Maecuru district and that from Ereré are different, and bear about the same stratigraphic and palæontologic relations to each other as the Corniferous group and the overlying Hamilton group of New York do, which Rathburn, therefore, considers as their equivalents.

The following forms of Platyceras are described: Pl. whitii (M.*), Pl. whitii var. curua (C), Pl. hussaki (M), Pl. steinmanni (M), Pl. hartti (M), Pl. symmetricum, Hall (E), Pl. symmetricum var. mæcuruense (M). There are three species of Diaphorostoma, viz., D. darwini (M and C), D. ? agassizi (M) and D. furmanianum Hartt and Rathbun (E). The genus Pleurotomaria is represented by one peculiar species, Pl. rochana H. et R (E). A Bellerophon (B. steltzneri) was brought from the Rio Curua and is described together with the similar B. morganianus H. et R. from Ereré. A Bucania (B. freitasi M) which has the proportions and probably the exterior of the B. leda of the Hamilton, and which may be also compared with Beushausen's Bellerophon macromyphalus F. Roemer, from the Spiriferensandstein was obtained at the Rio Maecuru. Among the Amazonian Devonian gasteropods, trilobed bellerophontids are strikingly abundant. There appear three distinct types of structure among them, namely one with a peripheral seam, and one without this seam, and a third type, embracing involute, laterally compressed shells having no seam. While Koken is disposed to regard Bucaniella as having possessed a seam, Clark restricts Bucaniella to the seamless, broad-backed Trilobatus (Conrad) group and describes two species as falling under this genus, viz., B. reissi (M) and B. coutinhoana H. et R. (E), the former of which resembles closely Roemer's Bellerophon globatus Sow., from the spiriferen-sandstein of the Hartz. For the second group (the broad, trilobed species having a seam) the name Plectonotus is introduced, and two species (Pl. derbyi and Pl. ? salteri, both from Rio Maecuru) referred to it. The third group, which has been described by de Koninck under the name Tropidocyclus, is represented by one species, T. gilletianus H. et R. from Ereré. The latter is somewhat similar in specific details to the B. brevilineatus of the Hamilton shales. For a peculiar bellerophont from the Rio Maecuru which is constructed on the type of the B. patulus of the Corniferous and Hamilton faunas, a new genus, Ptomatis, is proposed on the ground of its deviation from the bellerophont-type. The species is named P. forbesi. A peculiar Tentaculites (T. stubeli) with more or less oblique annulations which are separated by somewhat inequal intervals, thus suggesting certain annelid tubes, is quite abundant at the Rio Maecuru. Another species (T. oseryi) has been collected in the Rio Curua sandstones, and a third (T. eldredgianus H. et R.) at Ereré.

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*M signifies Mæcuru; C, Curuá, and E, Ereré.

The Pelecypoda are richly represented in the fauna of Maecuru. The essentially Devonian genus Actinopteria appears in two species, A. eschwegii, a form closely allied to the common Hamilton shale species, A. boydi, and A. humboldti. Another pterinaroid genus, Liopteria, has also been met with in two species, viz. L. browni and L. sawkinsi. The Modiolopsidæ are likewise well represented by the genera Modiomorpha and Goniophora; Modiomorpha with three species: M. helmenreichi (M), a form pointing by the remarkable flatness of its valves to an earlier Devonian fauna; M. sellowi (M), which exhibits strong specific relations to M. complanata from the Corniferous limestone; and M. pimentana H. et R. (E). The only representative of the genus Goniophora is G. woodwardi (E). The Trigoniidæ of the Rio Maecuru district present some interesting features. Two forms, closely allied to Schizodus transversus Beush, differ like this in several important characters, notably the structure of the hinge, sufficiently from the genus Schizodus to warrant the erection of a new genus Toechomya with the Brazilian species T. rathbuni (M), (directly comparable to Sch. tumidus of the Cornif. limestone) and T. freitasi (M). Two species of Sphenotus Sph. bodenbenderi (M) and Sph. groceixi (E), a close ally of the species S. cuneatus and S. truncatus of the Hamilton fauna), and two representatives of the Devonian genus Cimitaria; C. karsteni (M) and C. sp. (M), complete the list of the Trigonidæ. A single, not quite perfect valve from Maecuru suggests both the genera Nyassa, Hall and Guerangeria Oehlert (N. and G. ortoni). Cypricardella occurs in two species: C. hartti (M), one of the large complanate tenuistriate forms of the Corniferous, Hamilton and Spiriferen-sandstein groups, and C. pohli (M). Several large Grammysias assist in giving the fauna of Maecuru a typical Devonian aspect, viz. Gr. pissisi, similar to the Hamilton species G. alveata; Gr. burmeisteri, Gr. lundi, Gr. gardneri, Gr. ulrichi and Gr. sp. Hartt and Rathbun referred a fossil from Ereré to Pholadella parallela of the Hamilton shales, and Mr. Clarke abides by this determination. This, as well as Edmondia sylvana H. et R. (E) are figured. One of the best represented families of lamellibranchs is the Nuculidæ, for we find described and figured: Nucula bellistriata Conr. var. parvula (M., and Hamilton shales); N. kayseri (E); Nuculites smithi (M), which presents some similarities with N. oblongatus from the Hamilton group; N. ererensis, H. et R. (E); N. nyassa, Hall, var. majora sp. n.; and N. branneri (E); Palaeoneilo orbignyi (M); P. sulcata, H. et R. (E); P. pondeana, H. et R. (E); P. ? simplex, H. et R. (E); P. sp. (E), and Leda diversa Hall (E, and Hamilton shales).

At the end of the descriptive part, the author remarks on the exceedingly rare occurrence of bryozoans in these Devonian rocks, only a few fragments of Fenestella (probably F. parallela Hall, from the Upper Helderberg) and a Reptaria (perhaps identical with R. stolonifera Rolle from the Hamilton shale) having been collected.

The most interesting part of Mr. Clarke's paper is his concluding discussion of the interrelations of the faunas of the Rios Maecuru and Curua and the Ereré-Monte Alegre district, and of their degree of equivalence with faunas of other regions. The detailed study of the Brachiopoda of Ereré by Messrs. Hartt and Rathbun already determined the similarity of the fauna with that of the Hamilton shales and sands of New York. Also the earlier age of the Maecuru and Curua sandstones and the correspondence of their faunas to the Upper Helderberg was determined by Mr. Rathbun's study of the Brachiopoda. The trilobites of the sandstone of the Rio Maecuru have been described by Mr. Clarke (Archivos do Museu Nacional, vol. viii), who pointed out their strong early Devonian traits as well as the fact that as no other element of the fauna bears so strongly the impress of the earliest Devonian, this expression of the trilobitic element of the Maecuru fauna affects the time value of the entire faunal association. In striking contrast to the great development of the cephalopods in the lower and middle Devonian of other latitudes, these shells are entirely missing in the sandstones of the lower Amazonas. As "every fossil species has its time value," the author carefully ascertains the time-value of each component of the faunas described by him. Among the five species of gastropods, referred to Platyceras, there are none which suggest the common or characteristic nodous or spinous forms of the Upper Helderberg fauna of New York; the seamless trilobed Bucaniellas, like B. reissi, as well as the representatives of the new genus Plectonotus, point to forms of the Spiriferen-sandstein instead of to American Devonian faunas, while the type of structure represented by Bucania freitasi is evidently repeated in Bellerophon leda of the Hamilton group, and similarly Ptomatis forbesi finds its congener in P. patula of the Corniferous and Hamilton faunas.

Among the Pelecypoda, which in this fauna strangely outnumber the Brachiopoda, the common Actinopteria eschwegii is a new ally to A. boydi, so abundant in the Hamilton group of New York, and occurring in the Corniferous limestone of Ohio, the whole genus being eminently lower Devonian. The genus Liopteria, which is acmic in the middle Devonian, is represented by only one, evidently rare species, while the species of Modiomorpha are of types represented in the Schoharie grit and Corniferous limestone. The new schizodoid genus Toechomya shows affinities to species of the Corniferous limestone and Spiriferen-sandstein, while one of the Sphenoti (Sph. groceixi) is compared with a Hamilton form. Shells of the structure of the Cimitaria karsteni occur in the Spiriferen-sandstein, and one of the Cypricardellas (C. hartti) has its congener in the lower Devonian of North America and Germany, as well as in the middle Devonian of New York. The Grammysias belong to divisions which have no representatives in the North American fauna earlier than the Hamilton. Nucula bellistriata Conr., var. parvula represents a type elsewhere of middle Devonian import, and the Nuculites smithi finds its nearest ally in the Hamilton group. Paleoneilo orbignyi belongs to a middle and upper Devonian type of North America.

The brachiopods, which have been studied by Mr. Rathbun, are also subjected to an analysis to determine their time-values, and the following results are obtained: The species of Productella (M) is similar to P. shumardana of the Corniferous limestone at the Falls of the Ohio; Chonetes comstocki (E and M) can be compared with C complanata of the Orikany sandstein: Ch. freitasi and Ch. curuaensis belong to types common in the Upper Helderberg. A small brachiopod from the Curua-sandstone has been identified by the author with the Anoplia nucleata, which is often very abundant in the Oriskany sandstone, but occurs also in the Upper Helderberg limestone about Cayuga, Ontario, where the fauna embraces many characteristic Oriskany species. The species Sreptorhynchus (Orthothetes) agassizi is hardly distinct from O. chemungensis, especially from its earlier, more rigid subforms, as O. woolworthana. The numerous species of Spirifer occurring in the fauna do not yet allow of a precise comparison, but one form labelled by Rathbun as Sp. maecuruensis, bears a striking resemblance to the common North American Ambocoelia umboniata. The two Retzias (Rhynchospiras ? according to Clarke), described by Hartt, are of much interest, as similar forms have not been found above the Lower Helderberg. The Rhynchonella dotis from Ereré identified by Rathbun, is supposed by Clarke to be identified with the Corniferous limestone form Rh. sappho. The abundant occurrence of Amphigenia elongata in both the Maecuru and Curua sandstones is a striking character of the brachiopod faunas. Also Tripidoleptus carinatus and Vitulina pustulosa are abundant.

The fauna of the sandstone of Ereré reveals itself by its brachiopods trilobites, pelecypods, gasteropods and pteropods alike as a miniature of the Hamilton fauna; in fact, it is a more typical and better defined middle Devonian fauna than the latter, because it is equally free of types of earlier and of later Devonian faunas. Intercalated in the sandstones about Ereré are layers of dark shale, which contain Orbiculoidea lodensis, and Lingula spatulata, and are thus characterized as the equivalent of the Genesee shales.

The sandstone of the Rio Curua, while connected with the Maecuru sandstone by its brachiopod element, differs from the latter by the almost entire absence of the trilobites, pelecypods and gasteropods, so abundant in the Maecuru sandstone. Though it, therefore, may be properly regarded as a member of the Maecuru group, it does not contain the same fauna. Mr. Clarke suggests, on account of the much rarer occurrence on the Curua of fossils also known to exist in the Ereré fauna than on the Maecuru, that the Curua fauna is older than the Maecuru fauna. The Maecuru group probably embraces not only the Upper Helderberg fauna, but also elements that elsewhere precede this, and molluscan species that are elsewhere associated with middle Devonian faunas, thus furnishing another interesting instance of the commingling of Devonian faunas which are separated in central New York.

Finally is mentioned Mr. Derby's Curua group, consisting of black and reddish shales with no fossils but Spirophyton typum Hall and sporangia, which were described by Sir William Dawson as Protosalvinia, and considered as the fruit of Spirophyton typum.

A list of the fossils described from the Devonian faunas of the valley of the Amazonas with a table showing the vertical and geographical distribution of the same or allied specific type, increases greatly the usefulness of the publication. R. R.

Analysis and Composition [*of Roscoelite*]. By W. F. HILLEBRAND. (Am. Jour. Sci. 157, 451-454.)

Samples of this vanadium mica from Eldorado county, California, were analyzed by the author with a view to reconciling the discrepancies between the analyses of Roscoe and Genth, and to establish a satisfactory formula. A detailed description of the methods used in the determination of vanadium is given. The analyses varied from those of Roscoe in that no manganese or calcium was found, and from those of Genth in having over three per cent. more V_2O_3. M. L. F.

Chemical Constitution of Roscoelite. By F. W. CLARKE. (Am. J. Sci. 157, 454-455.)

From the analysis of Hillebrand the author has calculated the empirical formula to be $H_{453}\ K_{220}\ Fe_{22}\ Mg_{41}\ Al_{226}\ V_{318}\ Si_{753}\ O_{2724}$. Considering the groups SiO_4 and Si_3O_8 to be replaceable, the formula reduces to $R'_{678}\ R''_{63}\ Al_{226}\ V_{318}\ (SiO_4)_{536}\ (Si_3O_8)_{71}$, which would indicate, according to Clarke's mica theory, a mixture of three molecules representing respectively a normal phlogopite, a trisilicate alkaline biotite and a vanadium muscovite, the last forming 74.5 per cent. of the whole mass. M. L. F.

The Occurrence of Roscoelite. By H. W. TURNER. (Am. J. Sci. 157, 455-458.)

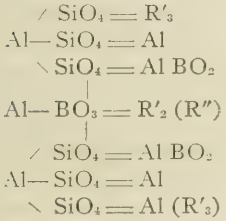
In each of the four localities in which this mineral occurs in California it is found that the quartz veins, and the associated gold and roscoelite occur near the contact of an intrusive granodioryte, either with some members of the Calaveras formation (Carboniferous) or with a serpentinic rock of late Jurassic or early Cretaceous time. The veins are later than the granodioryte and pass into it from the surrounding rock without interruption. The intimate association with the granodioryte suggests that the mineral may be regarded as due in some way to mineralizing solutions following the intrusion of this rock. M. L. F.

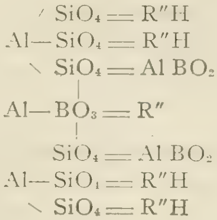
On the Chemical Composition of Parisite and a New Occurrence of it in Ravalli County, Montana. By S. L. PENFIELD and C. H. WARREN. (Am. J. Sci., 158, 21-24.)

The parisite occurs in a fine grained, friable, white substance resembling decomposed rhyolyte or trachyte, and is associated with numerous pyritohedrons of pyrite. It crystallizes in rather long hexagonal shafts made up of pyramids in oscillatory combination, and terminated by distinct, somewhat enlarged pyramids. A study of the analysis made by the authors indicates that parisite is probably a double carbonate of the formula $2(RF)CO_3\ CaCO_3$ or $(RF)_2\ Ca(Co_3)_3$ in which $R{=}Ce$, La, Di, etc. M. L. F.

The Constitution of Tourmaline. By F. W. CLARKE. (Am. J. Sci., 158, 111-121.)

Upon reducing to a common basis of six silicon atoms, the formula, $H_{11}\ Al_3\ B_2\ Si_4\ O_{21}$ of Penfield and Foote becomes $H_{16\frac{1}{2}}\ Al_{4\frac{1}{2}}\ B_3\ Si_{3\frac{1}{2}}\ O_{31\frac{1}{2}}$, while that of Clarke is $H_{14}\ Al_5\ B_3\ Si_6\ O_{31\frac{1}{2}}$. The author holds the view that these slight differences amount to no more than the uncertainties of the analyses, and in support of this view gives a series of formulæ computed from Rigg's data which show variations beyond both extremes, and make it probable that neither formula can be accepted without qualification as final. The intimate relation of tourmaline to mica is indicated by the alteration of the former to mica, by the parallelism in composition between the two when they occur together, and by the similarity in the commingling of isomorphous molecules in the two groups. Allied to muscovite, $Al_3(SiO_4)_3KH_2$, is the tourmaline acid, $Al_5(SiO_4)_6(BO_2)_2.BO_3H_2.H_{12}$, in which H may be replaced by Ca, Mg, Na, and Al. Numerous examples of mixtures of isomorphous molecules of this tourmaline acid are given. The formulæ advanced by the author as covering all established variations in composition, and rendering intelligible the various isomorphous mixtures, are as follows:





The objection to these formulæ, and also to that of Penfield and Foote as well, is that the end products contain no alkalies, while in reality an alkali-free tourmaline is unknown. Under these formulæ, the variations from the supposed ratio of silicon and boron of 2:1 are accounted for by the supposition that part of the bivalent group of atoms $=Al\text{-}BO_2$ is replaced by the similar groups $=Al\text{-}OH$ and $=Al\text{-}F$. Room for alternatives still exists, and future investigation may prove a derivation from a complex boro-silicic acid as yet unknown.

M. L. F.

Note on a New Meteoric Iron Found near Tombigbee River, in Choctaw and Sumter Counties, Alabama, U. S. A. By WARREN M. FOOTE. (Am. J. Sci., 158, 153-156.)

Detailed descriptions are given of the appearance, structure, and occurrence of six masses with an aggregate weight of nearly a hundred pounds. An analysis made by Mr. J. E. Whitfield showed 95 per cent. iron, 4 per cent. nickel, with small amounts of Co, P, C, and S. M. L. F.

An Albertite-like Asphalt in the Choctaw Nation, Indian Territory. By JOS. A. TAFF. (Am. J. Sci., 158, 219-224.)

This asphalt, which is found at several localities in the vicinity of McAlister in the southeastern portion of the territory, occurs as stringers in veins filling fissures along zones of thrust faulting in shales of unknown age. Although an analysis showed that in composition it was very similar to certain bituminous coals of the same region, its brittleness, easy fusibility, and more especially its distillation products, show that it should be placed among the asphalts. Of these it most clearly resembles albertite, the only important variation being the greater solubility of the latter in terpentine. M. L. F.

On the Separation of Alumina from Molten Magmas, and the formation of Corundum. By J. H. PRATT. (Am. J. Sci., 158, 227-231.)

The evidences bearing upon the separation of alumina from molten magmas as presented in the field by the various types of peridotytes of North Carolina are discussed, and an account given of the experiments of Morozewicz and their results. The conclusions are as follows: (1) Corundum will not separate out from a calcium-sodium-potassium silicate magma unless the ratio of alumina to the other bases is more than 1:1 and that of silica is less than 6. (2) It will not separate unless more than enough alumina is present to unite with all the magnesia and iron in the magma. (3) All alumina in a magnesium silicate magma, if there is no excess of magnesia, will separate as corundum. (4) If magnesia is in excess, the excess will unite with alumina to form spinel, the remainder separating as corundum. (5) In the presence of chromic oxide in a magnesium silicate magma, slight amounts of alumina and magnesia unite with the chromic oxide to form chromite, but corundum and spinel do not separate. (6) In peridotyte magmas containing alkalies or alkali earths a portion of the alumina unites with them to form feldspar. (7) The tendency of alumina to unite with alkalies or alkali earths to form double silicates is strong, but it has little tendency to unite with magnesia when the magma is a magnesium silicate. M. L. F.

Experiments relative to the Constitution of Pectolite, Pyrophyllite, Calamine and Analcite. By F. W. CLARKE and GEORGE STEIGER. (Am. J. Sci., 158, 245-257.)

The purpose of the examination was to gain evidence of the chemical structure of silicates by means of fractional analyses. I. Pectolite. The radiated variety from Bergen Hill, N. J., was analysed, the analysis giving the accepted formula $HNaCa_2Si_3O_9$. To determine if this represents a true metasilicate, the mineral was ignited, and afterwards boiled in a solution of sodium carbonate, with the result that a mean of 8.68 per cent. of silica (the amount proportional to the acid hydrogen) went into solution. Boiling the unignited material mineral in the sodium carbonate solution, or even with water alone, resulted in a slow decomposition with loss of both silica and bases. The loss on boiling for 16 hours in distilled water was 4.09 per cent. 2. Pyrophyllite. On strongly igniting, and treating with a solution of sodium carbonate, it was found that only 2.84 per cent. of silica was liberated, indicating that the mineral may with propriety be regarded as a basic salt of the acid $H_2Si_2O_5$ with the formula $Si_2O_5{=}Al{-}OH$. Pyrophyllite was only slightly attacked by heating with dry ammonium chloride. 3. Calamine. On igniting no definite fraction of water was split off. Boiling with sodium carbonate dissolved slight amounts of silica and zinc, but no breaking up into definite distinguishable fractions occurred. The evidence, though negative, is in favor of the usual formula $SiO_5{=}(ZnOH)_2$. 4. Analcite. On ignition and treatment with sodium carbonate solution only a slight amount of silica was split off, indicating the absence of metasilicic acid or an acid metasilicate. On heating with dry ammonium chloride there was again very little silica split off, but half of the sodium was converted to NaCl, and part of the water replaced by NH_3, giving a residue of $H_2Na_2Al_4Si_8O_{24}NH_3$. This points to the original formula of $Na_4Al_4Si_8O_{24}4H_2O$ which is contrasted with the usual formula

$NaAlSi_2O_6.H_2O$. The conclusion from the probable structural formula is that analcite is a member of the garnet-sodalite group.

M. L. F.

The Mineralogical Structure and Chemical Composition of the Trap of Rocky Hill, N. J. By ALEXANDER HAMILTON PHILLIPS. (Am. J. Sci., 158, 267-285.)

Numerous analyses of the trap and of several of the component minerals are given. The trap occurs in the form of a dike and in general appearance resembles a doleryte. In composition, however, it approaches closely to dioryte but with border phases allied to diabase. M. L. F.

Some Analyses of Italian Volcanic Rocks. I. By HENRY S. WASHINGTON. (Am. J. Sci., 158, 286-294.)

The analyses of the trachytes of the Phlegraean Fields and Ischia indicate that these volcanic rocks are not genetically related to the closely adjacent rocks of Somma and Vesuvius, but are connected with a second and older fracture line extending from Capraia to Sicily and covered largely by the waters of the Mediterranean. The rocks of this latter fracture show an excess of Na_2O over K_2O, while in the former K_2O and CaO predominate. A third fracture line, the oldest of the three, occurs far out in the Mediterranean and is characterized by rocks very high in Na_2O and possessing several peculiar sodium minerals. M. L. F.

Mineralogical Notes: Melonite, Coloradoite, Petzite, Hessite. By W. F. HILLEBRAND. (Am. J. Sci., 158, 295-298.)

An analysis of a nickel telluride from the Mother Lode region of California gave the formula $NiTe_2$, and is regarded by the author as probably identical with the melonite (Ni_2Te_3) of Genth which was obtained from the same locality. Other minerals recognized from this locality were coloradoite, petzite, and hessite. Analyses are given for the last two. M. L. F.

MONTHLY AUTHORS' CATALOGUE
OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Ami, H. M.

On some Cambro-Silurian and Silurian fossils from lake Temiscaming, lake Nipissing and Mattawa. (Ann. Rep. Geol. Sur. Can., vol. 10, part 1, appendix 2, pp. 282-301, Ottawa, Sept. 1899.)

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*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Anderson, F. M.

The Geology of Point Reyes peninsula. (Bull. Dept. Geol. Univ. Cal., vol. 2, No. 8, pp. 119-153, pl. 4, Aug. 1899.)

Bailey, L. W.

The mineral resources of the province of New Brunswick. (Part M, of the annual report. vol. 10, Geol. Sur. Canada, 129 pp., map, Ottawa. 1899.)

Barlow, Alfred E.

Report on the geology and natural resources of the area included by the Nipissing and Temiscamang map-sheets. (Part I, of the Ann. Rep. Geol. Sur. Can., vol. 10, pp. 302, plates.)

Clarke, F. W. (and G. Steiger)

Experiments relative to the constitution of pectolite, pyrophyllite, calamine and analcite. (Am. Jour. Sci., vol. 8, Oct. 1899, pp. 245-257.)

Clarke, John M. (James Hall and)

A memoir on the paleozoic reticulate sponges constituting the family Dictyospongidæ. 15th Ann. Rep. State geologist (of New York) for 1895, vol. 2, quarto, pp. 753-890, 47 plates, New York and Albany, 1898.

Crosby, W. O.

Geology of the Wachusett dam and Wachusett aqueduct tunnell of the Metropolitan waterworks in the vicinity of Clinton, Mass. (Tech. Quart., vol. 12, pp. 68-96. June, 1898.)

Dana, Edward S.

First appendix to the sixth edition of Dana's system of mineralogy, pp. x, and 74, New York, John Wiley and Sons, 1899.

Geikie, Sir Archibald.

Geological time. (Science, N. S., vol. 10, Oct. 13, 1899, pp. 513-527.)

Hall, C. W.

Exploration for gold in the Central states. (Proc. L. Sup. Min. Inst., vol. 5, pp. 49-60, 1899.)

Hall, James, (and John M. Clarke).

A memoir on the paleozoic reticulate sponges constituting the family Dictyospongidæ. Fifteenth annual report of the State geologist (of New York) for 1895, vol. 2, quarto, pp. 753-890, 47 pls. New York and Albany, 1898.

Hamilton, S. Herbert (and James R. Withrow).

The progress of mineralogy in 1898. Bull. No. 1, Am. Inst. Min. Eng., pp. 33, New York, 1899.

Hay, O. P.

On some changes in the names, generic and specific, of certain fossil fishes. (Am. Nat., vol. 33, Oct. 1899, pp. 783-792.)

Hay, O. P.

Descriptions of two new species of tortoises from the Tertiary of the United States. (Proc. U. S. Nat. Mus., vol. 22, pp. 21-24, 3 pls.)

Hillebrand, W. F.

Mineralogical notes; melonite coloradoite, petzite, hessite. (Am. Jour. Sci., vol. 8, Oct. 1899, pp. 295-299.)

Hobbs, W. H.

Emigrant diamonds in America. (Popular Science Monthly, vol. 56 pp. 73-83, Nov. 1899.)

Lambe, Lawrence, M.

Notes on a Stromatoporoid form from the Hudson River formation of Ontario. (Ottawa Naturalist, vol. 13, Oct. 1899, pp. 170-171.)

Palache, C.

Epidote and garnet from Idaho. (Am. Jour. Sci., vol. 8, Oct. 1899, pp. 299-303.)

Phillips, A. H.

Mineralogical structure and chemical composition of the trap of Rocky Hill, N. J. (Am. Jour. Sci., vol. 8, Oct. 1899, pp. 267-285.)

Scott, W. B.

The selenodont artiodactyls of the Uinta Eocene. (Trans. Wag. Free Inst., vol. 6, pp. 121, 4 pls., May, 1899.)

Stanton, T. W.

Mesozoic Fossils of the Yellowstone National Park. (Mon. 32, U. S. Geol. Sur., pp. 600-640, pls. 72-75, 1899.)

Steiger, G. (F. W. Clarke and).

Experiments relative to the constitution of pectolite, pyrophyllite, calamine and analcite, (Am. Jour. Sci., vol. 8, Oct., 1899, pp. 245-257.)

Washington, H. S.

Analyses of Italian volcanic rocks. (Am. Jour. Sci., vol. 8, Oct. 1899, pp. 286-295.)

Weeks, F. B.

Bibliography and index of North American geology, paleontology, petrology and mineralogy for the year 1898. Bull. No. 162, U. S. Geol. Survey, pp. 163, Washington, 1899.

Winchell, N. H.

A new iron-bearing horizon in the Keewatin in Minnesota. (Proc. Lake Sup. Min. Inst., vol. 5, pp. 46-49, 1899.)

Withrow, James R. (S. Herbert Hamilton and)

The progress of mineralogy in 1898. Bull. No. 1, Am. Inst. Min. Eng. pp. 33, New York, 1899.

CORRESPONDENCE.

MONOGRAPH XXXII, PART II, U. S. GEOLOGICAL SURVEY.—I beg to call your attention to the publication by this bureau of Monograph XXXII (Part II) of the Survey series, relating to the geology of the Yellowstone National park. It embraces chapters of the descriptive geology of the mountains surrounding the park plateau, by Mr. Arnold Hague and colleagues; elaborate investigations of the petrography of the crystalline rocks by Mr. J. P. Iddings; reports upon the invertebrate paleontology of the park and the Absaroka range by Messrs. C. D. Walcott, G. H. Girty and T. W. Stanton; and an exhaustive study of the fossil flora of the region, by Mr. F. H. Knowlton.

The volume consists of 893 pages, handsomely illustrated by 121 plates and numerous colored maps and figures. It can be purchased for $2.45. the actual cost of preparation, and payment should be made only by postal or express money order, stamps or checks being not acceptable.

Very respectfully,

CHAS. D. WALCOTT, Director.

Department of the Interior, United States Geological Survey. Washington, D. C., October 28, 1899.

PERSONAL AND SCIENTIFIC NEWS.

THE PROGRAMME OF INSTRUCTION in geology, at the Johns Hopkins University, for 1900, shows a staff of five resident lecturers and four non-resident lecturers. Mr. Bailey Willis, of the U. S. Geological Survey; Dr. Cleveland Abbe, of the U. S. Weather Bureau; and Dr. L. D. Bauer, of the U. S. Coast and Geodetic Survey are among the former. The announcement is made that the second course of the George Huntington Williams Memorial lectures will be given in April, 1900, by professor Brögger, of the University of Christiania, Norway. His subject will be "The Physical Properties of the Magmas of Eruptive Rocks."

This Memorial Lectureship upon principles of geology was fitly inaugurated in the spring of 1897, by Sir Archibald Geikie, director-general of the geological survey of Great Britain and Ireland.

The course given by Dr. Brögger will be anticipated with no less interest.

PROF. W. M. DAVIS has returned from fourteen months in Europe, to assume the position of Sturgis Hooper professor of geology at Harvard University. After the trip to central France, already mentioned here, three weeks were spent with Prof. Penck and his students in Bosnia and adjacent districts; the chief object of study being the carste phenomena, which were found to be *not* due to climatic control. Short trips followed with Heim, to an old landslide in Lindthal, and with Bruckner to the Tschingel glacier. On these and other excursions, the strong effect of glaciation upon Alpine valleys was especially studied. The last month of the vacation was partly filled by a trip across Norway and Sweden, the former with Dr. Reusch. Here the topographic effects of glaciation were noted. Near Christiania were found marine clays which repeat in great detail the features of the coastal plains of Maine. In Sweden, the escarpments west of Stockholm and the wall moraines were of great interest. The last days were spent in Berlin, at the seventh session of the International Geographical Congress, which was a marked success. During all the travels of Prof. Davis, dealers' collections of photographs were thoroughly inspected for landscape and structural views, for the Gardner Collection of Harvard University.

CAPT. A. W. VOGDES, United States Fifth Artillery, is at San Juan, Porto Rico.

DULAU & CO., of 37 Soho Square, London, have issued a new catalogue of miscellaneous geological literature, American and European, which they offer to send to any applicant, gratis. This company has had a long and extensive deal with geologists in America. Its fair and honest treatment of its patrons has secured for it their confidence.

THE STONY METEORITE which fell at Allegan, Mich., July 12th, 1899, has had a preliminary examination, and is found to consist largely of olivine and enstatite, with particles of metallic iron sprinkled through it. It is deposited in the National Museum, Washington.

ROBT. T. HILL has just completed an excursion through the cañons of the Rio Grande river, descending the river for 500 miles without seeing other human habitations than those of the cliff-dwellers.

OF THE OFFICERS OF INSTRUCTION IN THE DIVISION OF GEOLOGY at Harvard University, two spent the last summer in the field in Europe, two each in Montana, Nova Scotia and the Black Hills, and one in Alaska. Of the students occupied in research work, two each were in Colorado, the Black Hills, and New Brunswick, and one each in Nova Scotia and Alaska.

THE WISCONSIN ACADEMY OF SCIENCE, ARTS AND LETTERS has announced its annual meeting for December 28th, 29th and 30th. It will be held at Madison. It was chiefly through the agency of this academy that the Legislature was recently induced to establish the present flourishing Geological and Natural History Survey of that state. The society itself has issued twelve volumes of its transactions. These contain many papers on the geology of the state. This State Academy is one of the most active and useful in the country.

THE AMERICAN SOCIETY OF NATURALISTS will hold its annual meeting at Yale University, New Haven, December 28th. There will be an interesting discussion of the "Position that Universities should take in regard to investigation."

THE FAMILY OF THE LATE JOHN SIMKINS, who was congressman from Massachusetts, and a graduate of Harvard University, have given $20,000 to the Lawrence Scientific School of the University. The fund will be used to equip the mining and metallurgical laboratories, and a bronze memorial tablet will be placed in one of the rooms. *Science.*

DR. EDWARD ORTON of the Ohio State University, and state geologist of Ohio, died of paralysis at Columbus, O., October 16th. An appropriate sketch of his life will appear in a later number of THE GEOLOGIST,

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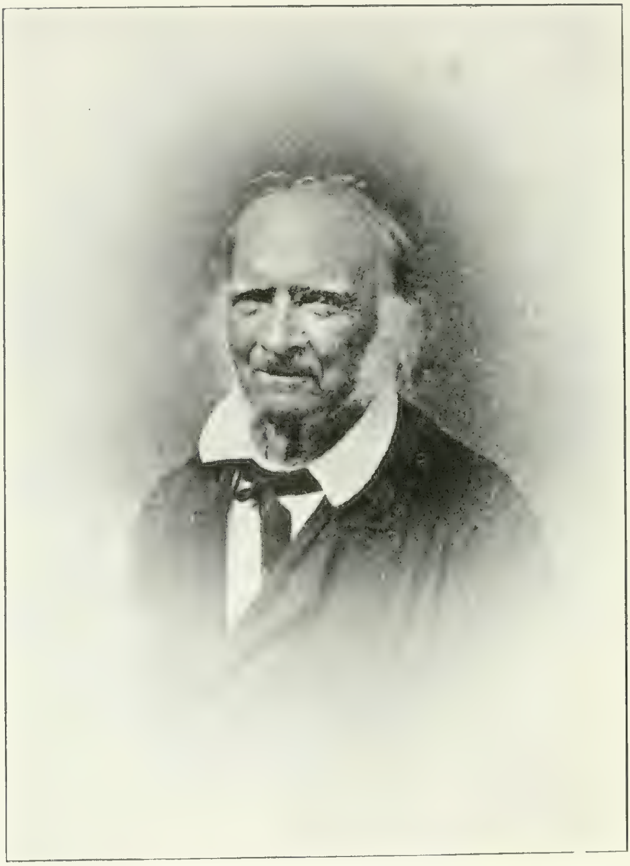

ISSACHAR COZZENS, JR.

THE

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BIOGRAPHICAL SKETCH OF ISSACHAR COZZENS, JR.

By CAPT. A. W. VOGDES, San Juan, Porto Rico.

(Portrait.)

Issachar Cozzens was a well known chemist and geologist, and one of the pioneers of the American school.

He was born at Newport, Rhode Island, December 15th, 1780, and died at Guttenberg, New Jersey, April 17th, 1865.

He was descended from Revolutionary stock, his father, Issachar Cozzens, was born in Providence, R. I., Aug. 21st, 1754, and died in New York, Jan. 18th, 1840, having served as a soldier and fought at Bunker's Hill. The wife of the elder Cozzens was a Miss Mary Daniels.

Issachar Cozzens, Jun., served in the War of 1812, and was a leading member of Tammany Hall in its early days, being treasurer of the society at one time.

He married Mary Ann Spinks April 14th, 1810. She died Sept. 6th, 1855. They had five daughters, the eldest, Debora Barnard Cozzens, died Nov. 14th, 1898. The youngest three were drowned at West Point, New York, June 22nd, 1838. The second daughter is still living.

The name and fame of Issachar Cozzens as a geologist are identified with the geology of the city of New York, from his well known "Geological history of Manhattan or New York Island, together with a map of the Island, and a suite of sections, tables and columns for the study of geology, particularly adapted for the American student, published in New

York in 1843," which is still considered an authority on this subject.

The author at first undertook to make a geological map with sections for his own amusement and study, to which he added historical facts, anecdotes and reminiscences of the city, so that the book might be interesting to the general reader, and "might induce some to read and become interested in the greatest of all sciences."

The book contains a geological history of New York city, with map, section of the palisades, section of Staten island, section at Stony Point on the Hudson, section of the rocks of Rhode Island with one of Niagara Falls, catalogue of minerals found in place on New York island, &c., in all 114 pages and 9 plates.

In Fairchild's history of the Academy of Sciences of New York, pp. 90-91, in some personal reminiscences by Prof. G. H. Redfield, I find the following: that "Issachar Cozzens was an early member of the lyceum, having been elected in 1822; at the time I entered, I think he must have been living out of the city, but afterwards he became a regular attendant, and after Dr. Gray went away, he was put in charge of the building, and for awhile towards the last of our occupancy I think he occupied one of the stores and sold minerals, fossils and shells. He was quite an old man, with venerable white hair, and I think he must have died poor."

Cozzens also published an article on the fossils of the falls of the Ohio in the American Journal of Science and Arts, but here at San Juan, Puerto Rico, I cannot give a reference to it.

The value of such a man's life and labors cannot be gauged simply by his publications. We must also take into account at this early stage of the science of geology the personal help and encouragement which he gave to others, and such services were at all times rendered frankly by Issachar Cozzens, whose genial nature and interest in the study of geology made it more pleasant and encouraged others, in these early days.

SHORE DEVELOPMENT IN THE BRAS D'OR LAKES.*

By J. Edmund Woodman, Cambridge, Mass.

(Plate XVI.)

Origin of the Forelands of the Bras d'Or.

In two papers Dr. F. S. Gulliver has written at some length of the formation of those projections now given the generic name "forelands." The first,† descriptive of only one variety, contains the following: "The present writer is inclined to attribute the attack of the sea largely to the waves, and its transporting action largely to the tides and currents." The table of contents divides the forms described into current, tidal, and delta cusps. The formative power of the wave, either in direct impact or in wave currents, is not considered. In the second paper,‡ which is elaborate in its treatment of constructional forms, essentially the same point of view is taken. A slight indication of belief in the efficacy of wave-formed currents is given (pp. 177, 178, 179), but it is evident that the chief emphasis is laid upon the larger currents of oceanic circulation. Such map studies fall into the weakness of regarding as genetically related, forms which merely have a similarity of appearance.

Prof. R. S. Tarr,§ in describing cusps in the Bras d'Or lakes and lake Cayuga, attributes their formation to waves, and throws out the suggestion that everywhere waves may have a large share in the construction of such features.

In order to discover the method of growth of the forelands of the Bras d'Or, two lines of approach must be employed: (1) watching the building operations wherever possible, from the shore and water; (2) ascertaining the conditions under which this building takes place, by all observations which can be made to bear upon the subject. If map interpretation were resorted to, it would be easy to treat the forms in the way this kind of work has usually been done heretofore.

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*The field work upon which this paper is based was done during the season of 1898. Hoping to revisit the region and extend the observations, I have held the notes then made; but as there is no prospect for a time of more study on the spot, it seems best to collect what is known of the phenomena, while previous papers are fresh.

†Bull. Geol. Soc. Am., vol. VII, pp. 399-422.

‡Proc. Am. Acad. Arts and Sci., vol. XXXIV, pp. 151-258.

§Am. Geol., vol. XXV, pp. 1-12.

The cusp which Prof. Tarr first describes—the recurved spit in Sidney harbor, which I take to be that locally called South bar, between the harbor and the South Arm—is hardly the best one for the case which he argues, on account of its position in a tidal estuary. By the process of map reading, it would undoubtedly be set down as due to violent tidal currents. But inquiry on the part of Prof. Tarr elicited the information that these currents are very feeble, and that no others of importance are known. There is little if any doubt here that wave action has been at least the dominant constructive force. Within the lakes themselves the conditions are yet more favorable to wave work, as opposed to that of currents.

Let us look at these conditions. The Bras d'Or lakes, as Prof. Tarr has stated in the paper referred to, are a series of northeast-southwest valleys, depressed sufficiently to afford the sea entrance at both ends. Thus salt and fresh water are mixed in their basins, with enough of the former to give a marine aspect to the fauna and flora. There is therefore a theoretical possibility of severe tidal action; but considerable inquiry on my own part and that of others has failed to discover this. In some places the rise is so small that, according to the inhabitants, although the water is salt there is no tide—which of course is not true. In others the rise amounts to about two feet. In no case, so far as I can ascertain, is there a tidal current of more than the weakest nature. I have satisfied myself by study of the eel-grass that a very faint movement exists in some parts; but it would be impotent to move more than the finest mud, and its power could be overcome by a slight breeze.

At the time when the drowning of these valleys occurred, the topography was varied; and as a result the margins of the lakes are sinuous, and a multitude of small and large hills now stand up as islands. The effect of this diversity, exceedingly pleasing to the eye, is to give many bays, fjords, islands, and the dead-waters that accompany them. All these factors, especially in the limited space occupied by the lakes, tend to give a maximum of shoreline for the area, hence greater opportunity for coastal erosion. But, on the other hand, these very sinuosities and islands so break up and restrict the sheets of water that it is difficult for the wind to form currents which would last for a considerable time, as happens on the open ocean shores. In addition to these diversities, the operations have gone on in water which is here shallow, there deep, but usually shallow as compared with that off the sea-coasts.

Aside from tidal currents, the agents which can be considered as operative in the work of constructing forelands not fed by river sediments are these: (1) currents of general oceanic circulation; (2) currents of considerable duration, the effect of prolonged wind action, often seasonal because of the dominance of a certain wind during that time; (3) currents caused by the unobstructed forward movement of the top water under wave growth and motion, and lasting little if any time after the cessation of the wind; (4) direct impact of the individual wave. The last two can properly be claimed under the general head of wave action. The first cause can be dismissed entirely as applied to these waters, because they are lakes and of small size. The second is invalid, for lack of evidence to prove its efficacy. Such observations as I have made, and such information as has been obtainable from others, lead to the conclusion that wind-impelled currents of long duration are not known in the lakes. By elimination, this leaves the last two as the agents.

But there are more valid reasons than these for regarding waves as the prime factors in the formation of the forelands. The character of the components of the spits and bars, the shape of the forms, and the observed operations of growth, not only can best be explained in this way, but cannot be accounted for by the theory of large-scale currents. In most instances the source of the material can be readily discovered, usually upon the nearest headlands. In size the particles range from sand up to small boulders, and driftwood is a characteristic feature of many bars. For these to have been transported and deposited by current action, it is necessary for the fragments, which must have fallen in some way within reach of these currents or been carried offshore to within their grasp by waves, to have been borne along as far as possible, and dropped when the current has lost power or the load become too great to be carried with the given rapidity of motion.

The consequences of these conditions are important, and can be applied to many cases other than those under consideration. In the first place, the material of any current-formed foreland can be no coarser at any time than can be carried by the maximum current which passes that point. In the Bras d'Or this would mean extremely fine particles. In very many other instances where by some physiographers currents are alleged as the chief if not the sole agent, this would mean finer particles than are found in some parts of the new forms. Exceptions to this could be made, of soft shores like the Atlantic from New Jersey southward. Indeed, it appears as though many of the ideas upon this subject have been obtained from a study of such coasts, and transplanted to the forelands which project from rocky shores. In the former instances, it may be that the currents have a proportionally greater effect, although even here the real evidence—from observation—usually fails to accompany the statement.

In the second place, currents cannot act above the level of high tide, or practically a little below that level. Hence any part of a foreland which projects above this must have reached that position by means either of winds or waves. Many of the spits and bars along soft shores owe their aerial portions to the winds in considerable measure; but there the particles are sand, of such size that the wind can carry them. Here, however, and in most cases along rocky shores, much of the material is too coarse for any winds to lift. This leaves waves as the chief agent of deposition, at least above high tide. In the Bras d'Or the tide is inconsiderable, in some places unnoticeable; hence the highest theoretically effective point of current action is somewhat below ordinary water level. But observations below water, as deep as can be seen from a boat, will show the presence there also of particles too large for current action to affect. Hence waves must be held accountable for the presence of these.

Another line of observation also discredits currents as effective constructive agents in these lakes; and as before, the same phenomena can be seen on many of the rocky coasts exposed to the ocean. In the first place, where the source is a headland and the form is not too small, the detritus can be traced directly from the point where it is fed from the bedrock, out onto the foreland. The individual particles become successively rounder and smaller away from the initial point, those nearest it being comparatively large and angular. It is unreasonable to suppose that these masses were taken offshore by currents, by currents were transported alongshore, and then raised into their present position. The continuity of the line of progressively rounder fragments, and the fact that the pieces are too large for the action of any observed currents, are conclusive evidence against this.

In the second place, the action of the waves can be observed directly. In heavy winds, waves of considerable strength are blown up on the larger parts of the lakes; and even in the smaller arms they may be capable of doing much work, when the relation of the major axis of the bay to the direction of the wind is right. The form and direction of these projections into the waters of bays, as Whycocomagh bay, where a through current is not possible, are such as winds would cause and are not such as currents would produce. In the high winds just mentioned, the travelling of particles alongshore at the water's edge can be observed by careful and continued watching, and it can be shown that masses above a small size frequently travel for some distance so close to the land that they can be kept in sight. Indeed, in places it has been possible to trace the path of a pebble in this migration, under different conditions of shoreline and wind. In his "Shoreline Topography" (p. 192) Dr. Gulliver says: "When more waste is supplied than the sea can deposit offshore, transportation alongshore begins." Direct observation here and elsewhere shows that, on the contrary, transportation alongshore need not depend in any way upon current, nor wait until a considerable shoal is formed in open water; but will take place at any time when there is a 'longshore component of wave force, often, as I have observed on the New Jersey coast, in direct defiance of a steady current.

The conclusions to which I have been led by observations on the shores of the Bras d'Or lakes, coupled with those on the ocean front of Cape Breton, Nova Scotia and northeastern United States, may be summed up as follows. (1) The forelands of the lakes, where not influenced by stream action, are formed by waves, generally not normal to the contact of land

and water. This is practically the conclusion expressed by Prof. Tarr. These forelands are functions of surface area and general depth of water exposed to the wind, rapidity and character of rock supply, change of outline of shore, change of submarine topography, and direction, intensity and duration of wave action. The equation is a very complicated one. The origin of the forms is usually, but not always, at a point of change in shore outline. In places it appears as though submarine topography must determine their presence, especially a shoaling of the water, making the wave lose force. In other cases material from a good feeding-ground travels along a nearly straight shore, till the waves lose their power with age and can no longer bear their load. Here a foreland begins. (2) On rocky shores in general, it is eminently probable that waves have a much larger share in constructive work than has been accorded them by at least one school of writers. On unconsolidated shores of fine material, the nature of the operation is still open to question; but on rocky shores I think it is observable that very many forelands are made chiefly by waves. (3) Each form, or at most each group of forms, must be studied by itself, through direct observation in the field, and all the environing factors carefully weighed, before the origin can be decided upon. On many coasts each case needs separate study. In such a region as the Bras d'Or lakes, which constitute for this purpose a small physiographic province, it is easy to determine that the conditions are similar throughout; and generalization sufficient to cover this area is not so hazardous after a fair number of typical forms have been studied.

Growth of Blunted Cusps in St. Patrick Channel.

Three miles and three and one-quarter miles east of the village of Whycocomagh, at the western end of St. Patrick channel, are two small forelands which do not fit exactly into any classification yet made. They lie, like many similar ones in other portions of the lakes, at points about midway between headlands. Some of the latter are scarcely more than a hundred yards apart, and the coves are not deep. The neighboring shoreline is only gently irregular. It has not been straightened much, but its outline reflects that of the initial stage after drowning. Were the coves deep, the deposits would partake of the nature of bay-head filling and would have straight or concave fronts. As it is, they project from the oldland into open water in the form of a blunt nose. They have nothing in common with pocket beaches, except that the material comes from the headlands on either side.

Their shape, position, structure, and material all indicate that they are the result of waves which have struck the headlands at an oblique angle, swept down the shore between them, and deposited their load at the apex of the very gentle curve which forms the outline of the cove. But this is not done as in the growth of a pocket beach. Because of the great breadth of the small indentations in proportion to their depth, the wave seldom splits on the headland, half running down either flank and giving two approaching waves which meet at the center of the bay; but if it splits at all on the headland, the larger part will be driven down the leeward side, little remaining to take the reflex path to windward. Thus while the wind is in one direction the waves transport down one side of the cove, apparently abandoning their load merely because it cannot be carried up the farther side. Yet the change in outline of the land at the point where the cape forms is never abrupt; and often, as in the two cases figured, the oldland has an almost straight margin. When the wind changes, the same operation takes place on the other side of the cove.

The cases illustrated in the accompanying figures show the results of the battle of the winds, which come now up the channel, now down. The oldland shore runs east and west, and the land to the north rises steeply. The channel, which over most of its course is such only in name, is one to two miles wide here. On the west, the head of Whycocomagh bay lies five miles away. The larger of the two forms (fig. 2) is about seventy-five feet east and west. The lines in the figures show the positions of successive ridges which mark the increase outward.

It will be noted that the growth was at first westward, as shown by the inner ridges. Whether the outline was ever that of a recurved spit it is impossible to say positively; but from the general environment and the present method of growth, I believe not. It appears rather that in the beginning two spits grew toward each other outward, finally meeting and inclosing a small lagoon. I have seen on adjacent shores many examples of the different stages. Thereafter came varying conditions of eastern and western supremacy. At the time the sketches were made, September, 1898, the dominant force was from the west, as shown in one by the small spit at its apex. The growth of the larger foreland was watched at intervals throughout several weeks, and slight changes in outline discovered. The increase could be seen in the case of the small spit at the end by a few hours of observation. The lagoons at the bases of the projections have become largely marshed up.

That these are not abnormal is shown by the fact that there are numbers of the same variety within a few miles, none of them large. Since their general shape would be cuspate were it not for the rounded apex, I have called them blunted cusps. The cause of the blunting appears to be the relation of wave direction to the shore, with the fact that the outer portion of the wave is always in deeper water than the rest, and thus loses less energy and is able to carry its burden farther, swinging it past the end of the cusp. The variable power of larger and smaller waves would also tend to keep the apex uncertain and blunt.

Classification and Distribution of the Forelands of the Bras d'Or.

As a whole the shores are adolescent. The rather gentle curves, the bay-head stream deltas, the bars, spits, cusps and tied islands all indicate this. In some cases where drumlins project into the water, a considerable portion has been cut away and the shore line well smoothed out.

The classification by outlines which is employed here is from "Shoreline Topography." Only a few of the instances can be given in each division, partly because of the multiplicity of examples, partly because a study of them would have taken a much longer time than was available.

Cusps.—Many cusps occur which form too small promontories to be given even local names. Some are typical in their outline, and as fine examples in miniature as any of the larger ones on open coasts, usually ascribed to currents. Others are more or less blunted. One type of these has been described above. Most of the large cusps of the ordinary shape have triangular lagoons within; and with some of them it is an open question whether they were formed as recurved spits, or as two spits converging outward by simultaneous growth. Some evidently have the former origin, as the opening into the lagoon can be seen near the base of one side. Others show no such gap, and certainly appear to have been formed by the latter method.

Of the former class are South bar, on the south side of Sidney harbor, described by Prof. Tarr; Allen point, north shore of Northwest Arm, four miles from the last; several, for the most part unnamed, on the south side of St. Andrew channel; northwest of Shenacadie, near the west end of Little Bras d'Or proper; six miles northeast of the last, forming the west side of Beaver cove; and Macdougal point and its eastward extension, northeast side of East bay—a fine example. These varieties grade gradually into ordinary recurved and hooked spits.

Of the cusps which have a closed lagoon, one of the best is Kelley point, northwest end of Barra strait. Others are a mile east of Porphyry point, East bay; Carey point, eastern part of Great Bras d'Or, which is in a sense intermediate, having at times a small outlet near the apex; Lockman point, St. Andrew channel, at the settlement of Boisdale; Dougal point, three miles northeast of the last; Big pond, southwest end of West bay; and Grande Grève, St. Peters bay.

Modifications of this form, as bluntly curved promontories projecting from an essentially straight shore and holding a lagoon, are found in Long beach, south of Seal id., in the narrow east end of Great Bras d'Or, which is the only case large enough to be given a name. At the east end of St. Patrick channel, two miles east of Murphy point on the south shore, is a smaller but well formed one. Early stages in the growth of closed cusps can be seen, showing two converging spits with a lagoon between, as the bars inclosing Goose pond, southwest shore of Little Bras d'Or, six miles east of Barra strait; and Maclean beach, four miles east of Shenacadie.

Loop bars.—Bars inclosing lagoons on the leeward side of islands are common. Examples are the northeast end of Kidston id., Baddeck bay; the west and south ends of Macdonald id., Whycocomagh bay, the latter compound; the west end of Maciver id., a mile from the last, also compound; and many islands in West bay, Inhabitants Basin, and Lennox Passage.

Uncompleted tombolos. —There are very few of these, as most islands have passed this stage. Wilson id., Great Bras d'Or near the mouth of East bay, has two cases. Others are Pringle id., south side of West bay; and a few off the mouth of Denys Basin.

Completed tombolos: single. — Of connecting bars there are great numbers, these and the bay bars perhaps constituting the majority of the forelands. They are at all stages and in various positions—connecting island with shore and island with island, and single, double and complex.

Single bars connecting islands with the mainland are seen in abundance at Denys Basin and West bay—as Macleod point, Morison head, George id., the head of Pellier harbor, and northwest of Malagawatchkt point in the latter; and west of Plaster cove in the former. Others are Double head, Lennox Passage; southeast of Jane point, St. Peters bay; Christmas id., west end of Little Bras d'Or; and Macphee id., East bay—a very crooked and complex case, in which three islands are tied to each other chainwise, and one of them to the mainland.

Connecting islands together are Indian id. and its south hook, Whycocomagh bay; the two parts of Cameron id., West bay, and of Indian head, Lennox Passage.

Completed tombolos: double. —Connecting islands with the mainland are Maciver id., west end of St. Patrick channel; and cape Round, Lennox Passage—one of the best, because of the divergence of the bars. The case is really a Y tombolo, because the bars meet at the back of the island.

Lagoon marshes.—Many cusps, especially small ones, have marshes behind them; but the large cases all show open water, occasionally with a little marshing in the corners.

Bay bars: across mouth.—The bay bars are innumerable, but most of the examples are small. Many illustrate stream deflection or complete damming up of the bay, the water escaping through the sand.

Cases with no deflection or damming are on the north side of Great Bras d'Or, nearly south of Benacadie point and a mile east of Campbell cove, two unnamed bays, both with bars from each side; Pellier harbor, north side of West bay, partly closed by one recurved spit; an unnamed harbor south of Macleod point, south side of West bay, two bars; Barrachois point in St. Andrew channel, described by Prof. Tarr, where the harbor of McLeod brook is nearly closed by a hooked spit which starts parallel with the north side of the bay, then turns south to close it up, nearly uniting with the mainland; mouth of Maccrutchie brook, west end of Little Bras d'Or, two bars; one-fourth mile southeast of Black point, south shore of same, two bars; Beaver cove, eight miles east of the last, already mentioned as a cusp with characters of a hooked spit; Benacadie pond, Great Bras d'Or at the mouth of East bay, one bar; Amaguadees pond and Christmas pond, north side of East bay, one long curved spit in each case; and an unnamed bay one-fourth mile west of the former pond, two straight bars.

A curious variation of the ordinary bay bars, which tend to run directly across the bay, is furnished in a few instances by bars which are turned sharply toward the head of the estuary, apparently because the wave action from without is vigorous, the river action from within slight. Examples of this are Head Bay cove, near the settlement of West Bay, at the head of the bay of that name, two bars, one much the longer; mouth of river Bourgeois, Lennox Passage, two short and strongly curved bars; and the mouth of river Tillard, Lennox Passage, one short bar.

Bay bars: across middle.—Instances are Baddeck bay; South Gut, St. Ann harbor; Campbell point in Malagawatchkt harbor, West bay, a very early stage; river Bourgeois, Lennox Passage, already referred to as having bars across the mouth. The last has two bars, the rest only one.

Bay bars: across head.—The only good case of this which has come to my knowledge is at the extreme west end of St. Patrick channel, north of the mouth of Blue's brook. The stream emptying there is merely a wet-weather rivulet, a few hundred feet long. The bar softens the angle which before marked the head of the bay, leaving a small triangular lagoon behind. In West bay, near where Ross brook empties from the north, a bar has run diagonally northwest almost across the head of a small indentation, and nearly shut off a diminutive body of water.

In none of the cases of bay bars is there more than a very small amount of filling behind.

Bay bars: damming and stream deflection.—Complete damming is effected only at the mouths of small brooks, chiefly those whose valleys before submergence began to widen near the present shore, and hence give only small bays. In other places, the indentation in the coast is not fed by any stream, and the bar merely makes a closed lagoon across the mouth of the embayment. Of the former, cases occur at Boisdale, south side of St. Andrew channel; on the side of Big harbor, almost opposite the last, on the north shore; Lochan Fad, south side of East bay; Irish cove, five miles southwest of the last; Kelly cove, north side of Great Bras d'Or, near Carey point; northwest end of Piper cove, north side of same, near mouth of East bay; on the same shore, one mile west of cape Dauphin; the lagoon behind Macdougal point, south side of East bay, already mentioned in another connection; and Campbell pond, south side of West bay. In most of these the stream is small. Besides those mentioned, there are several times as many examples scattered along the shores.

The streamless cases are for the most part minute, as all the other bays are fed by brooks of greater or less volume. One which is quite large, however, is found southwest of Macdonald id., Whycocomagh bay. Others are Gillis pond, south of the mouth of Denys Basin, also large; east of Militia point, northeast of West bay; two unnamed lagoons on the north side of Great Bras d'Or, east of Carey point; same shore, two miles west of Barra strait; Neilborn cove, Little Bras d'Or, one mile east of Barra strait; and McDonald pond, north side of East bay.

Winged beheadlands.—These forms are not well represented in the lakes. A small case is to be found on the south side of Great Bras d'Or, a mile north of Campbell cove. It may be that Dhu point and the shore west of it, north side of East bay, can be considered as an example, and the bars outside Lochan Fad and Lochmore on the south side of the same water. But Dhu point is very unsymmetrical; and the last two have no headland between, but instead a slight embayment, so that the whole form resembles a gentle ox-bow.

Bay-deltas.—Skye river and Roseburn brook, west end of

Whycocomagh bay, have filled the head of the bay for some distance, and make a delta well supplied with distributaries. Other streams show a slight beginning of this growth, but none have progressed far.

Deltas:—The only delta which pushes out into the open water is that of Middle river, Indian bay, on the north side of St. Patrick channel. It is quite strong, and would be minutely lobate, did not the waves plane its front off straight. It has pushed its way outward for some distance, however, and its three or four distributary channels attest the strength of the river current.

Spits.—There are many good spits, and a number other than those already mentioned under various heads. One of the best and most complex is Goulet beach, Lennox Passage. Another is Barrachois hook. Others are the south point of Indian id., Whycocomagh bay; south end of Wilson id., near Campbell cove, Great Bras d'Or; many instances in West bay and the mouth of Denys Basin; and Crow point, east end of St. Patrick channel—a complex case for one so small. Some of the best, for size and curve, are the bars outside of Amagdores and Christmas ponds, and Lochmore, all in East bay. Perhaps, also, the bars of Christmas island in Little Bras d'Or near Barra strait should belong in part to this group as well as to that of bay bars.

The objects in writing this paper have been three:—the proof of wave agency as the chief factor in the development of forelands in the Bras d'Or lakes, which could only be in addition to what Prof. Tarr has written; the description of a somewhat new form of cusp, if we accept Dr. Gulliver's admirable classification; and the enumeration of some of the forelands found in the lakes, chiefly to show that almost all the varieties given in that classification have representatives here, in abundance and in good form. The last brings out two points—the great richness of the field for the study of constructive shore features, and the fact that almost all the kinds of forms now recognized can be explained—*must* be explained here—without invoking the aid of currents. Some varieties of forelands are demonstrably current-formed; others are perhaps partly formed thus, or have their inception in currents and their main construction by waves. But to omit altogether the agency of waves seems error, in view of the field evidence afforded on lake and ocean shores alike, that waves have done practically all the work on some forelands, and have had a large share in a far greater number of others than has been believed by certain students of the subject.

Plate XVI.

FIG. 1. Blunted cusp, north shore of St. Patrick channel, three and one-fourth miles east of Whycocomagh. The southeast edge of the lagoon is a steep face, one foot high.

FIG. 2. Blunted cusp, one-fourth mile west of fig. 1; length, about seventy-five feet.

THE STONE REEF AT THE MOUTH OF RIO GRANDE DO NORTE, BRAZIL.

By J. C. BRANNER AND C. E. GILMAN.

Any person unacquainted with the stone reefs of Brazil, and seeing the one at Rio Grande do Norte, would find it difficult to believe that it was not a work of art. It stands like a long, low and nearly straight wall across the mouth of that river. Its total length is almost three miles, and in width it varies from 75 to 250 feet. It is barely covered by the highest tides. At its southern end it abuts against high cliffs; at its northern end it is cut off by the bar or entrance to the river and to the city of Natal. An old fort, within which is a lighthouse, stands upon the reef about two thousand feet south of the bar and nearly two miles from the southern end of the reef.

From the fort to its northern end at the bar the reef has deep water on both sides of it, but south of the fort it has sand dunes close to it with shallow pools of water from 100 to 600 feet wide between the reef and their sandy shore at high tide.

The surface of the reef has a gentle slope toward the ocean. This surface is etched and eroded in a peculiar manner. In places small flat pieces, a foot or two in diameter, are supported on a single leg like so many toad stools or

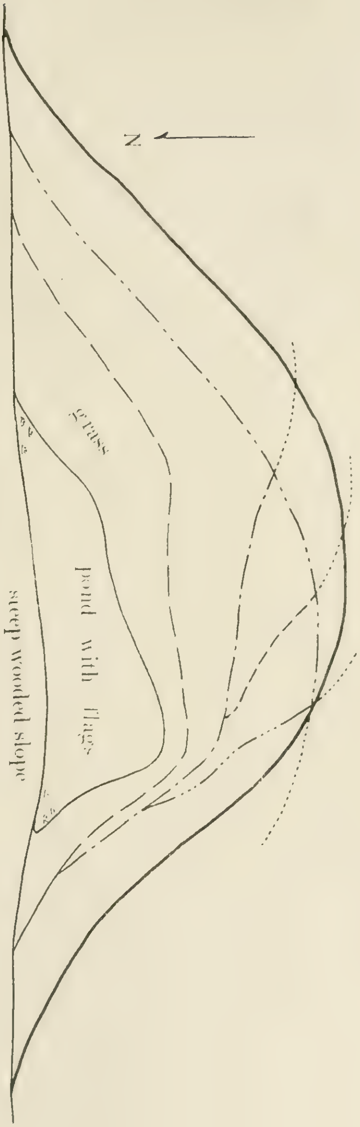

Fig. 1

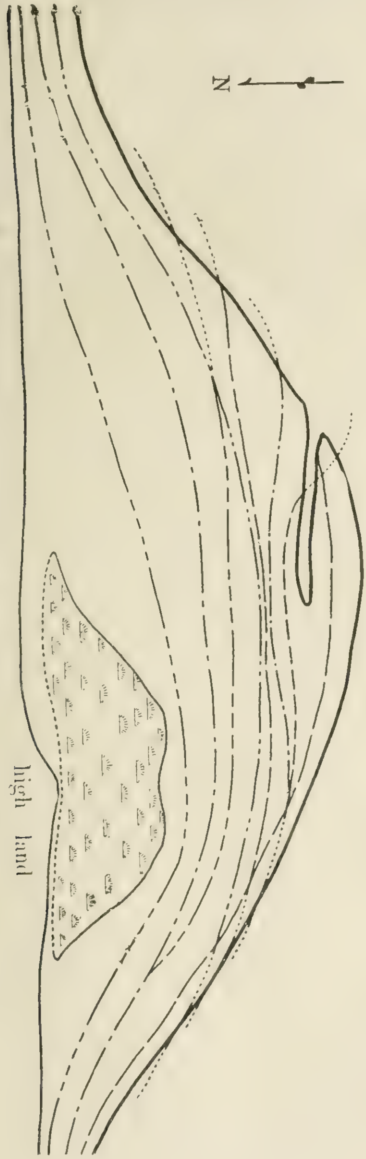

Fig. 2

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open umbrellas. These and other fantastic shapes with keen edges and points, render walking on the surface rather difficult in places.

Over a large part of its surface, and especially on the outer and inner faces where the rock is least exposed to the atmosphere, it is covered with algæ, corallines and barnacles to such an extent that the true character of the rock is not apparent. Upon being broken however in any part the rock is found to be a brownish yellow and very hard sandstone ringing under the hammer and containing large numbers of shells and water-worn quartz pebbles. A remarkable thing about the shells found in this reef rock, is that they seem to be of the same species as those found upon the present sand beaches in large numbers.

The reef is widest at the fort, and narrowest along its northern end, from the fort to the bar. Beginning at its southern end it has a bearing of N., 9° E. for about a mile. The first 3000 feet of this portion of it, resembles a jagged line of rocks and loose slabs, though here and then it is unbroken. Beyond this, for 2700 feet, it is one unbroken massive wall, with a gently sloping surface, its inner or landward face broken square off, and its outer edge protected by huge blocks broken from the main body and tossed about at all sorts of angles by the surf. Near the north end of this part of the reef it runs N., 17° E. and at this angle reaches a break about 180 feet wide and filled with loose blocks.

From this point the reef continues northward for 1800 feet to another break 80 feet wide, 1500 feet further north is another gap, and the direction of the reef changes to N., 4° E. There is no other break from this point to the end of the reef at the bar.

The directions given are magnetic bearings taken in June, 1899. It is worthy of note that while the course of this remarkable rock does change somewhat, in the main it is almost straight.

Another noticeable feature is that it seems to be accompanied throughout a part of its length by an inner reef that lies to the landward of and appears to dip beneath the main reef. It has been stated that the fort is built upon a wide part of the reef. This unusual width seems to be due to the union at this point of the inner and outer ones. From the fort the northern end of the inner reef appears to branch off somewhat from the outer one, and then disappears. On the opposite side of the river channel are some rocks which we did not ourselves examine, but they lie in the axis of this inner reef which fact leads me to infer that they are a part of this reef. A government engineer who at one time had charge of the port improvements at Natal stated to the senior author that these rocks were sandstones and were of the same character as the rocks of the reefs. Toward the south end of the main reef this secondary or inner one first shows about 1800 feet south of the fort. It is parallel with the outer reef and from 275 feet to 325 feet to the landward of it for about two-thirds of a mile. It is only from 30 feet to 100 feet wide, is composed of the same rock as the great reef, and is thickly coated with corallines and barnacles. At high tide this reef is covered by the water of the lagoon between the reef and the land. At its highest point it is only three feet above the sand flat about it, and at hige tide it is a foot or more under it.

The land immediately back of these reefs is rather low, but near the coast is made up chiefly of sand dunes. Behind or to the landward of these dunes are extensive tide marshes covered with mangroves. Only at their extreme southern end do they approach one of the high red bluffs so characteristic of the northeast coast of Brazil.

When we went to Rio Grande do Norte it was in the expectation that we should be able to photograph the reefs from the lighthouse, for views taken from that position would give a better idea of the form and character of the reefs than maps and verbal descriptions. This photographing was, most unfortunately, not permitted.

The subjects of the origin and history of the stone and other reefs of northeast Brazil will be treated later and at length by the senior author.

Natal, Rio Grande do Norte, July 2, 1899.

ON THE NOMENCLATURE OF CERTAIN AMERICAN FOSSIL VERTEBRATES.

By O. P. HAY, Washington, D. C.

In 1893, Prof. E. D. Cope[*] described from the Blanco beds of Texas a horse which he called Equus minutus. It will, however, be necessary to apply to this animal a new name, since the term minutus had already been employed to designate another, probably two other, species of Equus.

An Equus minutus was indicated by Marcelles de Serres in the year 1838,[†] but I have not been able to determine whether or not this name was accompanied by a description. For our present purpose this knowledge is not important. We have the following facts: In 1833 P. C. Schmerling[‡] figured and described, without naming, some teeth of a small horse, found in caverns of Belgium. In 1858 A. von Nordmann[§] wrote as follows: "Für die kleinen Pferdezähne, angezeigt von Schmerling aus den Lütticher Knochenhöhlen, ist von Marcelles de Serres die Benennung E. minutus vorgeschlagen worden." This application of the name to those figured teeth would of itself be sufficient to give the name validity. I have been unable to find any mention of this Equus minutus in works more recent than Gervais' Zoologie et Paléontologie francais, 2nd edition, 1859, where it is made a synonym of Equus adamaticus. This itself is a synonym of E. caballus. Trouessart[||] credits to Dubois an Equus minutus, regarding it also as a synonym of E. caballus, and omitting reference to place of publication. Dr. T. S. Palmer, of the U. S. Department of Agriculture, kindly informs me that Trouessart quotes the name and author from Roger's Verzeichniss, 1887, p. 46, in which place no additional information is vouchsafed. If Dubois has described as new an Equus minutus, it too antedates Cope's species of that name.

For the latter I propose the name Equus phlegon.[**]

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[*] Prelim. Rept.. Vert. Palæont. Llano Estacado, p. 67, pl. XX, figs. 8, 8a, 8b.

[†] Essai sur les cavernes de l'Aude, 1838, p. 117. (Quoted by Gervais, in Zool, et Paléont. francais, ed. 2, 1859.)

[‡] Recherches sur les ossemens fossiles decouverts dans les cverns de la Province de Liége, vol. II, p. 142, pl. XXV, figs. 3, 5.

[§] Palæont. Südrusslands, p. 158.

Catalogus Mammalium, 1898, p. 794.

[**] Interea volucres Pyrois Eous et Aethon,
Solis equi, quartusque Phlegon, hinnitibus auras
Flammiferis implent, pedibusque repagula pulsant.—*Ovid.*

I wish to make some remarks on certain fossil reptiles of North America.

In 1856 Dr. Leidy* described a new genus of dinosaurian reptiles from the Judith River beds of Montana, and this genus he called Deinodon, the single species being D. horridus. A more extended description with figures was published by Dr. Leidy † in 1860. When these descriptions were written Dr. Leidy was in doubt whether all the teeth comprehended under the name which he gave belonged to a single species or even a single genus. Some of the teeth, represented by figures 21-34, plate IX, as cited, resemble those of Megalosaurus and are broadly elliptical in section, with two denticulated carinæ, on opposite sides of the crown. Other teeth, represented by figures 35-45, are somewhat U-shaped in section, with one nearly plane surface, corresponding to the top of the U, and this surface is bounded on each side by a denticulated carina. But none of these teeth was especially designated as types of the genus Deinodon.

In 1866 Prof. Cope‡ in considering these teeth, restricted the genus Deinodon (spelled Dinodon, however) to the teeth represented by figures 35-45 of Dr. Leidy's plate. The Megalosaurus-like teeth, represented by figures 21-34, Prof. Cope regarded as belonging to his own genus Lælaps. In 1868 Dr. Leidy§ again took up the subject; and refusing to be bound by Prof. Cope's action, he retained Deinodon (with the orthography Dinodon) for the teeth of figures 21-34; while for the others he proposed the new generic name Aublysodon, the species being called A. mirandus. In the same year Prof. Cope,‖ replying to Dr. Leidy, defended his own procedure, but accepted Dr. Leidy's generic name Aublysodon on the ground that "Dinodon" had been preoccupied by Duméril and Bibron for a genus of snakes.

Undoubtedly, Prof. Cope, being the first to distribute the materials of Dr. Leidy's composite species and genus, had entire right to assign the original name to such part thereof as he chose, and succeeding writers ought to have respected his work. Hence, Dr. Leidy's original generic name adheres to the teeth represented by figures 35-45 of his plate and not to the others. On the other hand, Prof. Cope erred when he undertook to improve Dr. Leidy's name by writing Dinodon and again when, with this emendation as a basis, he accepted Aublysodon. Were Deinodon Leidy and Dinodon Duméril and Bibron derived from the same Greek words, *δεινος* and *῾οδων* it would not be necessary first to emend Deinodon to Dinodon to produce interference. But, while Leidy's Deinodon is undoubtedly derived from the Greek words written above, Duméril and Bibron's Dinodon is not so derived. If we turn to the famous work on reptiles by the author* just mentioned, we find this explanation of their generic name: "Ce nom a été imaginé par Bibron, d'après l'examen de l'individu confié par M. Smith. Il semble composé de *Δι*, par le milieu, de chaque côté, utrinque, et de *Νοδως*, édenté."

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*Proc. Acad. Nat. Sci. Phila., 1856, p. 72.

†Trans. Amer. Philos. Soc., vol. XI, p. 144, pl. IX, figs. 21-48.

‡Proc, Acad. Nat. Sci. Phila., 1866, p. 279.

§Proc. Acad. Nat. Sci. Phila., 1868, p. 198.

‖Amer. Jour. Sci., [3], vol. XLVI, p. 415.

This being the case, Dr. Leidy's name, in its original form Deinodon, is not preoccupied and is the proper name to apply to those species which for many years have been arranged under the generic name Aublysodon.

It may be remarked here that more recently Prof. Cope† has emended also the Dinodon of Duméril and Bibron into Dianodon.

The disposition of this case above detailed, which disposition I believe to be uncontestable, on the assumption that two distinct genera are included in the lot of teeth described by Leidy, leaves those teeth represented by figures 21-34 without specific name. It is possible that they are covered by some of the specific names which have been included under Prof. Cope's genus Lælaps, but apparently they are not. Hence, I believe that I am justified in giving them a provisional specific title.

The name Lælaps, having been employed in 1835 for a genus of Arachnida, is not available in the sense given it by Prof. Cope. Hence, Prof. Marsh‡ properly substituted for it, in 1877, the name Dryptosaurus. To this genus then the teeth represented by figures 21-34 of Dr. Leidy's plate IX seem to belong. They may be called Dryptosaurus kenabekides.*

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*Erpétologie Générale, vol. VII, 1854, p. 447, footnote.

†Trans. Amer. Philos., Soc., XVIII, p. 205.

‡Amer. Jour. Sci.,[3], vol. XIV, p. 88.

From the time of Leidy's first description there have been some reasons for suspecting that all the teeth described by him belonged to the same genus, indeed to the same animal. All those teeth were found "in one place and possessed the same structural differences." Again, Prof. Cope in describing his Lælaps incrassatus† states that he found that the anterior denticulated carina of some of the anterior teeth was moved around the crown so that it was no longer opposite the hinder carina; and he says that a further transferrence would produce a tooth like those of Leidy's figures 35-45, those with the U-shaped section. Furthermore, Cope says that he found a large tooth in immediate association with the jaw of his L. incrassatus, but separated from it, which had the posteriorly truncated section described by Leidy as typical; and Cope believed that this tooth belonged to the maxillary bone, near the position of the superior canine of a mammal.

Nevertheless, in 1892 Prof. Cope‡ had the opportunity to study remains of L. incrassatus which furnished him nearly all parts of the skull; and he did not find, either in the maxilla or in the dentary, teeth of the kind represented in Leidy's figures 35-45. The teeth of the premaxilla were missing in his specimen and there remains the possibility that they are the ones which possess the U-shaped section. Meantime, it seems wiser to retain the genera as distinct, awaiting further discoveries.

The name Axestus was proposed in 1872 by Prof. Cope for a genus of trionychid tortoises, found in the Eocene deposits of Wyoming. The species A. byssinus was further described and figured by Prof. Cope in 1884.§ The name is however preoccupied. It may be modified into Axestemys. Axetus was employed in 1834 by Dejean for a genus of beetles.

Mr. J. Z. Gilbert ‖ has described the skull of a species of

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*The Kenabeek, the great serpents,
Lying huge upon the water,
Sparkling, rippling on the water,
Lying coiled across the passage,
With their blazing crests uplifted.—*Longfellow's Hiawatha.*

†Proc. Acad. Nat. Sci. Phila., 1876, p. 341.

‡Proc. Amer. Philos. Soc., vol. XXX, p. 240.

§Tertiary Vertebrates, p. 116, pl. XV, figs. 1-12.

‖Kansas Univ. Quart., vol. VII, p. 143, with 4 text-figures.

Testudo from the Loup Fork beds of Kansas and identified it with Prof. Cope's T. undata, described* from the Loup Fork deposits of New Mexico. Since nothing is known of the latter species except a few marginals and a costal bone, there is really no evidence that the fine skull described by Gilbert belongs to T. undata. The probabilities are greater that it belongs to one of the species described by Prof. Cope† from the Loup Fork beds of Kansas, Testudo orthopygia and T. cyclopygia. Of T. orthopygia Prof. Cope possessed most of the skeleton including the skull. A comparison of Mr. Gilbert's figures and description with the description of Prof. Cope makes it pretty certain that the former is not identical with T. orthopygia. Of T. cyclopygia the skull is not known, and we have no means of comparing it with Mr. Gilbert's species. This being the case, it is better, I believe, to give the latter a distinct name, so that its literature may be kept separate until further discoveries demonstrate its relationship to other described forms. I name it in honor of its describer Testudo gilbertii.

CROSSING THE VALDEZ GLACIER, ALASKA, AT BATES BAY.‡

By Captain W. R. Abercrombie.

Everything being in readiness July 27, the fog set in so dense it was decided not to attempt to cross the glacier until landmarks could be discerned. July 31 Private Garrett was sent up on the third bench of Valdez Glacier to bring in eight prospectors who had lost their way in attempting to cross Bates Pass. Some of these men had been on the glacier for five days, and during that interval had abandoned everything —guns, clothing, and food. The action of the fog seemed to be governed by the warm, moist air rushing in through Port Valdez from Prince William Sound, which, when striking the cold air blowing over the glacier through Bates Pass, rose rapidly and was precipitated as snow and sleet on the summit and rain in the valley below. There was rain and fog August 1, 2, 3 and 4, and the humidity was so pronounced and so continuous that bacon and ham became one mass of mold, while, the water of crystallization in the sugar being liberated, the sugar wasted away in the form of a sirup. One thousand three hundred pounds of commissary stores at the camp in Valdez were exchanged for an equal amount in the interior, thus obviating the packing of this amount over the glacier.

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*Wheeler's Survey West of 100th meridian, vol. IV, p. 283, pl. LXVII, figs. 1-2.

†Bull. U. S. Geol. and Geog. Surv. Terr., vol. IV, 1878, pp. 393, 394.

‡Extracted from "Reports of Explorations in the Territory of Alaska" made under the direction of the Secretary of War, 1898, No. XXV, Washington, July, 1899.

August 5, notwithstanding the foggy, rainy weather, the expedition was ordered to proceed at once for the interior. Camp was broken at 5 a. m. At the foot of the glacier Private Bence was found, and when asked what he thought of the prospect of getting over the summit, replied that if the wind shifted and the pass was missed, that the stock and outfit stood a chance of being a total loss. On the arrival of the train at the foot of the glacier each section of it was inspected. Each section consisted of five horses, each horse being led by a man, and there was also an extra man and extra rope to each section. The instructions to the men were to proceed over the glacier at given intervals as a unit, and whenever a horse broke through a snow arch over a crevasse they were all to join at once in roping and pulling him out without unpacking. After seeing that everything was in its place, the train started, with Private Bence, with pickax and alpenstock, in the lead. I followed, leading my horse, on which I had packed a 5-gallon keg of whisky, to use as a stimulant during the night and the following day.

Passing onto the glacier, the animals seemed to know instinctively that there was danger ahead, as they would tremble and keep their noses close up to the backs of the men who were leading them. Whenever they broke through a snow arch, as they often did, they would lie perfectly still until roped. This applied equally to those which had been extremely shy and hard to approach prior to leaving the camp on the beach. As the expedition passed up through one crevasse, and turned to make an ascent of some 50 or 60 feet up a grade of not less than 45 degrees, onto the cone of a hogback that was obscured in the thick fog, some of the civilian employees were inclined to be a little weak-kneed, as it looked very much like climbing up the fog into space. But by a judicious use of the stimulant referred to, this was overcome, and, placing them along in the niches cut by Private Bence, we roped the entire train up with but few accidents. Now and then a horse would lose his footing and go down to the bottom with a rush. But as the trail was constructed so that all the attendants and packers were on the upper side of the horses, nothing worse than bruises and cuts to the animals was the result of their falls. Never once did one of them refuse to climb out of an ice gulch when called upon, although many times they left a trail of blood behind them when the disintegrated rock of the moraine had cut them in their falls.

Arriving on top of the first bench, the fog was so dense that it was impossible to see more than five or six animals of a train at any one time. It was like a man groping his way in the dark, and at the end of two hours' traveling the expedition was completely lost. Every once in a while it was found that the melting ice had caused one of the stone monuments which had marked the trail to slide from its position. Then a halt would be called and Bence sent forward in the fog, just far enough to keep within hail. Having found the continuation of the line of monuments, he would call back and the train would move forward again. These were trying moments. In this way the train was kept moving during the day and well into the night, until 12 miles had been covered up the glacier. Here a bivouac was made for the night, as it was becoming so dark that one could not see to go farther in the rain that had been falling in torrents the greater part of the day. The picket line was stretched from one ice hummock to another, the pack animals tethered, and the cargoes removed from the pack saddles. As the rain was extremely cold, the saddles and blankets were left on the animals to protect them as much as possible. Their grain was portioned out on the ice.

To each man in the party a small tincupful of whisky was issued, some canned meat, cheese and hard-tack. Some of the men pitched their shelter tents on the glacier and attempted to sleep; but in a few minutes they joined their comrades, who kept up a steady tramp all night backward and forward in rear of the picket line. I here take occasion to remark in this part of my narrative that during my twenty-two years of service on the frontier I never experienced a more desolate and miserable night. Not only was the night black, but the rain was continuous. Occasionally the mighty glacier would crack as it settled in its passage to the valley below, with a vibration that would cause the men to stop in their tramp and the horses to nicker with apprehension, if not fear. Then would follow a deafening roar as some thousands of tons of ice was detached from one of the hundreds of glaciers that fringed the mountain sides. As these high fields of ice and snow would come crashing down onto the main glacier they would bound from wall to wall of the canyon, and the echo would die out finally down the valley many thousand feet below. Like all other nights, this one came to an end. At daybreak another allowance of whisky was issued to the outfit, and the animals were packed and the party proceeded on its way toward the summit.

Four or five miles were covered, when a section of the glacier was encountered that was so bisected with crevasses of such width that for a while it was a question of getting through. But taking the train down a long narrow peninsula of badly crevassed ice, an outlet was found which could be doubled back on. The expedition was now in a position where it was as dangerous to go back as it was to go ahead. The mental strain on all at this stage of the journey was terrific. Progress was very slow; not more than a quarter of a mile an hour for the next three or four hours was made. Working in and out of this mass of crevasses we finally crossed what was known as the fourth bench, and found ourselves on better footing. Up to this point the glacier had been free from snow. A zone was now reached where the snow and slush were about knee deep, through which we plodded. Looking up toward the summit of the pass, the eye could not define where the sky line began and the snow ceased. In the middle of this zone, which was limited only by the range of vision, was a beautiful stream of clear water, with a deep blue bottom. It seemed in perspective, being so rapidly foreshortened by the fog, to be a blue column ascending into the sky. Following up the banks of the stream there suddenly flashed out through the fog the panorama of the fifth bench, which was composed of huge ice cliffs, through which the wind shrieked and moaned in a most weird and unearthly manner, at an extremely high rate of speed.

During all this time the march had been confined to the center of the glacier. A course to the right was now chosen, and we struck off for the mountain on the right of the pass, with a view of avoiding the fifth bench and striking the snowslides on the right-hand side of the pass. This is the point where so much stock was lost early in the season from avalanches. A number of snowslides were reached which were packed as hard as ice, and over which the expedition traveled a number of miles, until the foot of the summit was reached.

This summit is where the glacier comes off the top of the mountain and is an abrupt descent of about 1,100 feet in the mile, or about one in five. The effort required to climb this pitch can be realized, in a measure, when it is understood that to make twenty yards of the ascent at once taxed the wind and energy of the strongest mountain climber. The four animals and five men ahead on the trail resembled small birds following each other as one looked at them far above in the fog. Halting at intervals of 5 or 10 yards, the summit was finally reached. The wind was blowing a hurricane through the pass into the interior, accompanied by gusts of sleet and snow, which, freezing as fast as they struck, coated men and beasts with an armor of ice. At this point, having a lighter load than the others, I found myself in the lead. I halted to wait for the rest of the party, but soon found that if I did not keep moving I would freeze. My horse also suffered severely from the cold. The wind was terrific. In vain I tried to catch some landmark to guide me in laying my course through the pass. If I made a mistake and left the pass by one of the feeders that came in from the higher peaks on each side, the remark of Private Bence of the day previous would be verified.

To stand still was impossible. The only thing left to do was to simply drift with the blizzard, and this I did. Fortunately for the expedition, the point at which the summit was reached was exactly in the middle of the pass, and whenever an attempt was made to veer either to the right or left from the true course of following through the pass the sleet cut the faces of the men so they would turn their backs to the storm and proceed in the proper direction. Had the wind blown into the pass from the right or left the expedition would have simply drifted out onto the great glacial fields. As the storm continued for several days, the men would have been snowed in, and probably the entire outfit frozen to death, as no living man could face the gale. But as luck was on the side of the expedition, it drifted through the pass and down toward the Klutena Valley.

After some five or six hours' travel in the howling storm, where it was impossible to hear or see a comrade, a high and rocky cliff was finally rounded and the expedition beheld the most beautiful sight I ever witnessed. The change was almost magical. Two yards after passing behind the shelter of this rocky cliff there was a perfect haven of rest and sunshine, while out of the pass rushed the howling storm like the water out of the nozzle of a fire hose. Throwing ourselves on the snow in the sunshine, we stretched ourselves at full length and enjoyed that rest which only men can who have been battling for their existence. As if understanding the situation, the poor, miserable-looking pack ponies, their manes and tails all clotted with ice, lay down in the soft snow and grunted with satisfaction as the rays of the sun peeled the coating of ice off their bodies. After resting here a short time and eating lunch, the expedition proceeded down the glacier to the timber line. Here camp was made for the night in a grove of stunted cottonwoods and willows. I had now successfully crossed the Valdez Glacier at a season of the year when it was universally conceded to be impassable for man, making the journey in twenty-nine consecutive hours of practically continuous work, without sleep, rest, or shelter. The command was, however, in bad shape. The men were more or less frost-bitten about the ears and hands, and the pack animals bruised and lacerated to such an extent as to render some of them unfit for service. After enjoying the luxury of the camp fire and relating to each other our various narrow escapes, we rolled up in our sleeping bags and soon forgot the past in the sound and pleasant sleep that comes to the weary man in the field.

SOME FURTHER NOTES ON THE WEATHERING OF DIABASE IN THE VICINITY OF CHATHAM, VIRGINIA.*

By THOMAS L. WATSON, Atlanta, Georgia.

Statement.—In a former number of this journal,† the writer published the results obtained from a careful study of the weathering—transition from fresh to decomposed, incoherent rock—of one, of the Mesozoic diabase dikes, near Chatham, Virginia. The data indicated that in passing from the fresh to decomposed rock, the transition was accompanied by an unusually large loss in the alumina,‡ which has, hitherto, been considered one of the most refractory constituents, by investigators working along similar lines—serving in many cases as the constant for calculating the loss and gain in the other constituents.

No explanation was offered at the time, as the work was considered too local, and not extensive enough, to warrant any statement to account for this condition. Soon afterwards, however, the writer was given the opportunity to collect and examine a similar series of specimens from an adjacent dike, for the purpose of covering the same ground as in the former paper, with the view of seeking a satisfactory explanation for the loss in alumina.

Location and description of rock: The dike is cut across by the Southern railroad one mile west of Chatham, with an exposure in width at this point of something over 150 feet. The railroad cut is about 25 feet deep, consists of large and small boulders piled on one another, which become smaller and almost completely decomposed near the top of cut, where they are wholly embedded in a light yellow stained, mottled clay—a product of residual decay from the diabase rock. The limit of decay—weathering—is, in other words, considerably below the depth of cut.

Megascopically, the rock is dark gray in color, and uniformly speckled with white flecks of feldspar. It is a medium grained diabase revealing apparently equal amounts of the dark colored ferro-magnesian minerals and white feldspar, in which occurs a fair sprinkling of finely divided grains of pyrite. The light colored feldspar and quartz can be readily distinguished from the dark colored ferro-magnesian minerals. Microscopically, the rock is an aggregate of somewhat idiomorphic lath-shaped feldspars, with the interstices filled with allotriomorphic plates of augite, some olivine, magnetite and quartz. The olivine displays the usual alteration to serpentine along certain lines. The augite varies from colorless to the merest tinge of green in transmitted light, is generally non-pleochroic, and shows patches of uralite and chlorite as alteration products. A number of the best plates of augite showing $\infty P \breve{\infty}$ cleavage gave an average extinction, with this plane, of 33°-35°. The ∞P cleavage was rather imperfectly developed. The parting parallel to $\infty P \breve{\infty}$ was well developed, imparting, in most cases, somewhat of a diallagic appearance to the mineral.

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*The writer is indebted to Prof. Geo. P. Merrill, Head Curator, Dept. of Geology, U. S. National Museum, for kindly reading and commenting on the paper in MS. form.

†Watson, Thos. L., Weathering of Diabase near Chatham, Virginia, Am. Geol. 1898, 22, 85-101.

‡Ibid.

Analyses of the Augite.

	I	II	III
SiO_2	50.71	49.33	48.33
Al_2O_3	3.55	9.15	4.41
Fe_2O_3	....	0.27	*10.01
FeO	15.30	9.05	......
MnO	0.81	.....	......
CaO	13.35	16.36	20.51
MgO	13.63	14.58	17.11
Na_2O	1.48	0.55	......
K_2O		0.19	......
Igni	1.17	0.25	......
	100.00	99.73	100.87

I. Augite in West Rock, Conn., Hawes, G. W., Proc. U. S. Nat. Mus., 1881, p, 132.

II. Augite in hypersthene diabase, Culpepper Co., Va., Campbell and Brown, Bull. G. S. A., 1891, 2, 344.

III. Augite in olivine diabase. Chatham, Va., Watson. T. L., Am. Geol., 1898, 22, 88.

A few scattered shreds of secondary biotite were noted.

Micrographic intergrowths of feldspar and quartz are rather common in the thin section.

Optical properties indicate the presence of two feldspars, the principal one of which gave an average extinction of 27° with $M = \infty P \breve{\infty}$ (010), corresponding to Ab_1An_2. A still more basic feldspar than this is indicated, corresponding to about $Ab_1\ An_{12}$.

In 1881, Dr. Geo. Hawes* published on the mineralogical composition of the Atlantic border Mesozoic diabase, and pointed out the fact that the feldspathic element in the normal type of this rock does not consist of any single feldspar. The following table of analyses indicates the kind of feldspar occurring in this type of rock in various localities:

	I		II		III
	Sp. Gr. over 2.69		Sp. Gr. under 2.69		
SiO_2	52.84	.880	60.54	1.010	45.95
Al_2O_3	28.62	.278	24.11	.234	34.70
Fe_2O_3	1.52	.009	1.14	.007	0.64
MnO	.....	....	.....	.....	.....
CaO	11.81	.210	9.15	.163	15.82
MgO	0.46	.010	0.27	.107	1.80
K_2O	0.86	.009	1.06	.011	0.45
Na_2O	2.38	.038	4.11	.066	
H_2O	1.06	....	0.59	.....	0.96
Total	99.55		100.97		100.32

	IV		V		VI		VII
SiO_2	57.820	.973	55.345	.922	51.40	.922	51.18
Al_2O_3	28.160	.276	27.299	.267	30.98	.267	27.00
Fe_2O_3					0.22		3.19
MnO							0.17
CaO	7.720	.139	12.284	.219	13.40	.219	11.70
MgO					0.45		1.92
Na_2O	5.352	.087	5.072	.081	2.85	0.81	0.41
K_2O					0.39		3.48
H_2O loss	0.720						1.19
Total	99.772		100.000		99.69		100.24

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*Hawes, G. W., on The Mineralogical Composition of the Normal Mesozoic Diabase upon the Atlantic Border. Proc. U. S. Nat'l Museum, 1881, 129-134.

I. Feldspar in Jersey City Diabase—Ratio:
$RO : R_2O_3 : SiO_2$ 1 : 1 : 3.3 $R_3O : RO$ 1. 4.7
Labradorite.
Hawes, G. W., op. cit., p. 131.

II. Feldspar in Jersey City Diabase—Ratio:
$RO : R_2O_3 : SiO_2$ 1 : 96 : 4.09 $R_2O : RO$ 1. 2.2
Andesite.
Hawes, G. W., op. cit., p. 131.

III. Feldspar in West Rock, Conn. Diabase—Anorthite. Hawes, G. W., op. cit., p. 131.

IV. Feldspar from Dike 67, Trembleau Point, near Port Kent—Ratio: $R_2O : RO : R_2O_3 : SiO_2$ 1 : $\frac{3}{2}$: 3 : 11
Andesite.
Kemp and Marsters, Bull. U. S. G. S., No. 107, p. 24.

V. Feldspar in Olivine Diabase, Chatham, Virginia. Ratio:
$R_2O : RO : R_2O_3 : SiO_2 = 1 : 2 : 3 : 11$.
Labradorite Ab_8An_9
Watson, Thos. L., Am. Geol. 1898, 22, 89.

VI. Feldspar in Hypersthene Diabase, Culpepper Co., Va.—Ratio:
$R_2O : RO : R_2O_3 : SiO_2$ 1 : 5 : 6 : 17
5 $(Ca_2Al_4Si_4O_{16})$: $2(Na_2Al_2Si_6O_{16})$ 5An : 2Ab
Chemical properties indicate Labradorite. Optical properties point to Anorthite.
Campbell and Brown, Bull. G. S. A., 1891, 2, p. 343.

VII. Feldspar in Diabase, SE corner, Sec. 13, T. 47 N., R. 46 W., Michigan.
Corresponding to Labradorite, with formula Ab_1An_2
SiO_2 51.34 % Al_2O_3 31.20 % CaO 13.67% Na_2O 3.79 %
Labradorite.
Van Hise, C. R., Monograph, U. S. G. S., xix, p. 352.

VIII. Feldspar in Diabase, Medford, Mass., according to Merrill and Hobbs is Labradorite and Orthoclase.
Merrill, G. P., Bull. G. S. A., 1896, 7, 350.
Hobbs, W. H., Bull. Mus. Comp. Zoology, 1888, 16, No. 1.

It is apparent from this tabular statement that the feldspathic constituent in the normal diabase of the Atlantic border consists of the basic members of the plagioclase series, ranging from basic labradorite through andesite to anorthite, the most basic one of the feldspar group. When it is remembered that the basic members of the feldspar group yield more readily to atmospheric agencies than do the more acid members of the series, the above point is significant as bearing on rock degeneration.

The weathered product. The sample representing the decayed portion of rock was taken from the railroad cut about fifteen feet below the surface, in order that any effects produced by cultivation, might be eliminated. The sample was selected with great care, and was taken from several points along the cut, at approximately the same depth, and the several portions intimately mixed, from which the final sample was obtained. The sample showed a medium light yellow colored, finely pulverulent mass, through which was distributed a large amount of fine lumpy material. The lumps readily crumbled under the gentlest pressure of the fingers, and while generally coated over with a staining of iron oxide, and occasionally some manganese oxide, the general outline of the original fresh minerals could be readily distinguished. The feldspar areas were very much lighter in color than those of the augites. When broken and examined under the microscope a considerable quantity of the fresh minerals was recognizable. The appearance of the material under the microscope was that of a light yellow colored spongy mass, made up of fine shred-like grains, with a good sprinkling of the partially decomposed minerals. The feldspar areas were filled with a very white looking material having all the appearance of a crystalline body, but when examined under crossed nicols no extinction occurred, hence these were taken to represent an amorphous product resulting from the feldspathic decay.

After repeated digestion of a portion of the decayed rock, in a very dilute solution of hydrochloric acid, until all ferric oxide had been removed, the mass was seen to be made up of an aggregate of medium sized particles of a white material, considerably speckled by a darker colored mineral which was taken to be augite—a microscopic examination of the leached product revealed feldspar centers, highly doubly refracting, inclosed by amorphous masses of kaolin.

Chemical analyses and their discussion.

Chemical analyses of the fresh and decomposed rock are given in the accompanying tables, which indicate the nature of the rock-weathering. By assuming one of the constituents in columns I and II as a constant factor, the results given in columns III, IV, and V are obtained.

Calculated loss of material in the fresh and decomposed rock.

Constituents	Fresh I Bulk analysis	Decomposed II Bulk analysis	Calculated amounts saved and lost III Percentage loss for entire rock	 IV Percentage of each constituent saved	 V Percentage of each constituent lost
SiO_2	51.08	42.07	21.66	57.59	42.41
Al_2O_3	23.58	32.05	1.17	95.04	4.96
*Fe_2O_3	6.85	9.83	00.00	100.00	00.00
CaO	9.36	0.95	8.69	7.10	92.90
MgO	4.95	1.38	3.98	19.51	80.49
MnO	0.39	0.48	0.04	87.27	12.73
Na_2O K_2O	2.34	1.11	1.56	33.23	66.77
Igni	.....	12.13	00.00	†100.00	00.00
Total	100.00	100.00	37.10 %	......	.....

Columns IV and V show the percentages saved and lost, respectively, for each constituent calculated on an iron constant basis. Of the individual constituents, 42.41 per cent of the SiO_2, 4.96 per cent of the Al_2O_3, 92.90 per cent of the CaO, 80.49 per cent of the MgO, 12.73 per cent of the MnO, and 66.77 per cent of the alkalis (Na_2O+K_2O) have disappeared, equivalent to a total loss for the entire rock of 37.10 per cent.

Out of the 37.10 per cent, total percentage loss for the entire rock, approximately two-thirds of the whole, or 21.66 per cent, is SiO_2; 8.69 per cent, or a fraction more than one-fourth of the whole, is CaO; a little more than one-tenth, or 3.98 per cent, is MgO; while the Al_2O_3 and K_2O+Na_2O combined only amount to about one-fifteenth of the whole. It is at once noticeable from the table that the greatest total loss for the rock is in the three constituents SiO_2,CaO and MgO, the sum total of the three removed by solution, amounting to 34.33 per cent; the remaining 2.77 per cent of the 37.10 being divided between the Al_2O_3, alkalis and MnO. Attention is here called to the slight loss in the Al_2O_3, which is accounted for later on in the discussion. The relative loss in the remaining constituents is in accordance with and proportional to that observed by others in the study of similar and related rocks.

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*Iron was determined as total F_2O_3.

†Gain.

We have in this case, an example of weathering in which, apparently, the thorough decay and disintegration of the rock, through extensive hydration and oxidation, has been accomplished, with a loss in the original constituents amounting to slightly more than one-third of the whole, or 37.10 per cent. While the total amount of material removed, 37.10 per cent, in solution, in the transition from the fresh to the decomposed rock, is probably something above the average for basic eruptives, the character of the decomposition product indicates that the change is far from being complete.

The following tabular statement compares the soluble material in the fresh and partially decomposed rock, and the soil of the Virginia diabases, extracted by digestion in 100cc of N/^{2}HCl for three hours, at the temperature of boiling water.

	Fresh rock	Partially decomposed rock	Soil
Soluble matter	20.43%	20.57%	34.05%
Soluble matter*....	31.81%	28.71%	49.72%

Calculated loss of material in the fresh and partially decomposed rock.

	Fresh	Partly decomposed.	Calculated amounts saved and lost.		
Constituents	I	II	III	IV	V
	Bulk analysis	Bulk analysis	Percentage loss for entire rock.	Percentage of each constituent saved	Percentage of each constituent lost
SiO_2........	51.08	51.00	2.96	94.20	5.80
Al_2O_3	23.58	24.40	0.55	97.63	2.37
Fe_2O_3	6.85	7.29	0.00	100.00	0.00
MnO..	0.39	0.46	....	......	.....
CaO....	9.36	8.78	1.07	88.50	11.50
MgO....	4.95	4.39	0.80	83.77	16.23
Na_2O....	.....	.....	....	......	.....
K_2O....	.....	.....	....	......	.....
Igni	.....	2.76	....	......	.....
			5.38 %		

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*Amer. Geol. 1897, *22*, 93, 94.

This table represents the percentage gain and loss indicated by the transformation from the fresh to the partially decomposed rock. It is introduced to show the comparison between this and a similar stage in the weathering of an adjacent diabase dike.* The partially decomposed material—analysis given in column II—was taken from one of the inner concentric (shelly) layers of a boulder which required only a moderate degree of pressure from the hand to break it into pieces. That a change (weathering) in the original fresh rock had taken place was manifested in the medium discoloration of the component minerals. It is only necessary to call attention to the change by hydration and oxidation, which has been accomplished with a total loss of only 5.38 per cent, of which loss, the SiO_2 amounts to more than one-half. In the case of the similar stage of weathering in the adjacent dike, the change was accompanied by a total loss of 7.4 per cent, in which the SiO_2 shows the second greatest loss among the constituents. The greatest loss was in the MgO, and is readily explained as having resulted from the easily decomposable mineral olivine, in an olivine diabase.

Of the individual constituents, 5.80 per cent of the SiO_2, 2.37 per cent of the Al_2O_3, 11.50 per cent of the CaO, and 16.23 per cent of the MgO have disappeared in the change.

The comparison for the two similar stages in weathering for the two adjacent dikes, is well brought out in the table below, which gives the total loss for rock, per each constituent:

	I	II†
SiO_2	2.96	0.99
Al_2O_3	0.55	0.00
F_2O_3	0.00	0.79
CaO	1.07	0.15
MgO	0.80	5.47
Total loss for rock, per cent	5.38	7.40

The alkalis, Na_2O and K_2O, were not determined for this stage. It has been shown, however, that the total loss for the two is something under one per cent.

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*Loc. cit. p. 93.

†Loc. cit. p. 93.

Analyses of fresh and of decomposed diabase from Mount Holyoke, Massachusetts.

	*Fresh	†Decomposed	Calculated amounts saved and lost		
Constituents	I	II	III	IV	V
	Bulk analysis	Bulk analysis	Percentage loss for entire rock	Percentage of each constituent saved	Percentage of each constituent lost
SiO_2	52.68	53.70	19.73	62.54	37.46
Al_2O_3	14.14	13.00	6.16	56.42	43.58
Fe_2O_3	1.95	21.00	00.00	100.00	00.00
$Fe_2O_3 = 12.83$					
FeO	9.79	......	.....	......	.....
MnO	0.44	0.19	0.32	26.76	73.24
CaO	9.38	0.70	8.95	4.58	95.42
MgO	6.38	0.15	6.28	1.44	98.56
Na_2O	2.56	......	.....	......	.....
K_2O	0.88	......	.....	......	.....
Ignition	1.60	8.50	00.00	‡100.00	00.00
S. and loss	.....	2.76	.....	......	.....
Total per cent	99.80	100.00	41.44	......	.....

This table shows analyses of fresh and of decomposed trap (diabase) rock from Mount Holyoke, Massachusetts, made at different times, by separate analysts. The percentages lost and gained for each constituent, and for the entire rock have been calculated on an iron constant basis and introduced for sake of comparison. The figures in column II represent an analysis of many years' standing, and since it is not possible to know how representative the material yielding them was, they must be accepted as interesting only as confirmatory. The analyses will serve to show the changes which have taken place in the transformation from the fresh to the decomposed rock.

Excluding the alkalis, which were not determined in the decayed product, the table indicates a total loss of 41.44 per cent, distributed almost entirely between four constituents, viz: SiO_2, equalling nearly one-half of the whole, or 19.73 per cent; Al_2O_3, 6.16 per cent; CaO, 8.95 per cent; and MgO, 6.28 per cent.

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*Average of two analyses made by Dr. G. W. Hawes of the compact trap rock from Mount Holyoke, Mass. Am. Jour. Sci., 1875, 9. 186.

†Analysis of decomposed trap from the east end of Mount Holyoke, Mass., made by President Hitchcock. Economic Geology, p. 135.

‡Gain.

The special features to which attention need here be directed are: (1), the change in passing from the fresh to the decayed rock is accompanied by a loss of nearly one-half of its original constituents, 41.44 per cent. (2), The large assumption of water—hydration—which is a natural consequence. (3), The disappearance of 43.58 per cent of the original Al_2O_3. This loss in the alumina constituent is in accord with the writer's* work on one of the Virginian diabases.

The MgO, CaO and Al_2O_3 have suffered the greatest loss among the individual constituents. The figures opposite iron in column II would indicate that the change has been accompanied by a complete oxidation of the ferrous to ferric iron and its subsequent retention.

Table showing the total percentage loss for entire rock for each locality.

	I	II	III	IV	V	VI	VII	VIII
SiO_2	33.41	21.66	19.73	8.48	20.92	15.04	30.34	17.43
Al_2O_3	9.11	1.17	6.16	0.00	3.27	0.00	0.00	0.00
Fe_2O_3	0.00	0.00	0.00	2.42	0.00	9.10	16.64	3.53
MnO	.....	0.04	0.32	0.32	.....	.....	.....	.....
CaO	9.71	8.69	8.95	1.83	8.05	9.60	3.46	9.20
MgO	15.09	3.98	6.28	0.68	5.12	6.83	6.77	4.97
K_2O	0.35	1.56	.....	0.62	0.33	3.39	1.51	0.21
Na_2O	2.04		.....	0.50	1.82		1.40	2.17
P_2O_5	..	....	....	0.08	....	....	....	...
Igni.	0.00	0.00	0.00	0.53	4.18	0.00	0.00	0.00
Loss, per cent.	70.31	37.10	41.44	14.93	39.51	43.96	60.12	37.51

I. Olivine diabase near Chatham, Virginia. Am. Geol. 1898, 22, 95.

II. Diabase one mile west from Chatham, Virginia.

III. Diabase from Mount Holyoke, Massachusetts. Loc. cited.

IV. Diabase from Medford, Massachusetts. Bull. G. S. A., 1896, 7., 355.

V. Diabase from Spanish Guiana, Venezuela. Quart. Jour. Geol. Soc., London, 1879, 35, part 2, 586; Bull. G. S. A.

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*Loc. cit.

VI. Basalt from Kammar Bull, Bohemia. Rocks, Rock Weathering and Soils, N. Y., 1897; p. 223.

VII. Basalt from Crouzet, in the Haute Loire, France. Ibid. N. Y. 1897, p. 223.

VIII. Dioryte from Albemarle County, Virginia. Bull. G. S. A. 1896, 7, 357; Ibid.—N. Y. 1897, p. 225.

This table has been compiled from all available authentic analyses of fresh and decomposed diabase and other closely related rocks, and indicates the total loss for the entire rock, in its transformation from the fresh to the decayed state, for each locality given. It is significant in that it affords a ready means of comparing results, recorded from localities of widely varying latitudes, where the usual common factors employed in the processes of weathering are probably different in action. A certain agent, or group of agents, predominating and rendered intense in action for one place, becomes subordinated in action in the transformation of the fresh rock to that of a residual product—soil—for another latitude.

The figures in each column give results on material, whose corresponding decomposition product varied somewhat widely from the original fresh rock, and in those cases where examined consisted of a more or less incoherent mass of sand, gravel and clay. Megascopically, the change was apparently complete, although in some cases, when rubbed between the fingers the residue was found to be gritty—due to undecomposed particles of the original minerals. When, however, upon digestion in dilute acid and examined under the microscope, the decayed product revealed a greater or less abundance of the original minerals, in apparently fresh condition—proving that the change or transformation was not complete.

This change is apparently capable of more or less definite chemical expression. In those cases where disintegration of the rock has been accomplished mainly through physical forces and but little effected chemically, the analyses indicate a small total loss for the entire rock; while, on the other hand, where the rock degeneration is in the nature of true decomposition, promoted and brought about through chemical processes, a proportionately large total loss is shown. Other things being equal, the more complete the decomposition, and the nearer the final limit in the decay is approached, the greater the total loss.

This is well illustrated, on the one hand, by the granitic rocks of the District of Columbia, where Prof. Merrill* found that the transformation from fresh rock to soil was accompanied by the very small total loss of only about three (3) per cent. The alteration in this case, as concluded by Dr. Merrill, was evidently physical, attended with but slight chemical effect. As an example illustrating the transition from fresh to decayed rock, in which the change was in an advanced stage and one of true chemical decay, may be cited the Virginia diabase,† where the writer found the large total loss for the rock to equal 70.31%. (See column I of table.) The basalt from Crouzet, France, column VII of table, shows a loss of 60.12 per cent.

Apart from the chemical analyses of the fresh and decomposed rock, mechanical analyses of the decayed portion of two of the rocks represented in the above table, have been made, and become quite significant, when taken in connection with the results in the above table. In both cases the analyses were made in the laboratory of Prof. Milton Whitney, chief of the Division of Soils, Washington, D. C. For convenience of discussion they are herewith appended:

Name	Diam. of particles in mm.	Per cent. I‡	Per cent. II§
1. Gravel	Above 2 mm.	42.3	0.00
2. Fine gravel	2. — 1. mm.	20.66	0.00
3. Coarse sand	1. — .5 mm.	12.72	3.21
4. Medium sand	.5 — .25 mm.	9.37	13.10
5. Fine sand	.25 — .1 mm.	4.97	15.39
6. Very fine sand	.1 — .05 mm.	4.18	23.49
7. Silt	.05 — .01 mm.	1.13	23.98
8. Fine silt	.01 — .005 mm.	0.37	4.16
9. Clay	.005 — .0001 mm.	1.67	14.20
10. Loss at 110 degrees		0.66	.....
11. Ignition		1.73	.....
Total		99.76	97.53

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*Bull. G. S. A., 1895, 6, 324.

†Loc. cit.

‡Diabase—Medford, Mass.—Merrill, Geo. P., Bull. G. S. A. 1896, 7, 352.

§Diabase—Virginia—Watson, Thos. L., Am. Geol. 1898, 22, 92.

A glance at the above table is sufficient to show the difference in the physical state of the two rock products. In the case of the Medford rock, it is found that the three grades, 7, 8 and 9, representing, silt, fine silt and clay, respectively, correspond to only 3.17 per cent of the whole, while in the case of the Virginia rock these correspond to 42.34 per cent of the whole. These three grades in the above table may safely be taken to represent the actual decomposed portion of the rock, although some particles of undecomposed minerals may, at times, be present in grades 7 and 8.

The clay content, which is truly decomposed material, amounts to 14.20 % in the Virginia rock as against 1.67 % in the Massachusetts. In examining the table of losses for the entire rock, we find that the results on chemical analyses, for the same two rocks, columns I and IV, indicate a total loss, respectively, of 70.31 per cent, Va., and 14.93 per cent, Mass. That is to say, the transformation from the fresh to decomposed rock in the Virginia locality is accompanied by a total loss of 70.31 per cent, which is equivalent in the mechanical analyses of the residual product to 42.34 per cent; and similarly for Massachusetts a total loss of 14.93 per cent, equaling 3.17 per cent of the actual decomposed clay.

It appears, therefore, that a certain fairly definite relationship exists between the mechanical and chemical analyses. That the mechanical work affirms whether or not the degeneration is wholly chemical or physical, or a combination of the two; and further indicates which of the two was the most prominent in breaking down the fresh rock.

The table shows that the degeneration in the Virginia rock has been principally due to chemical work, while that of the Massachusetts is due principally to the work of disintegration (physical forces) aided by decomposition (chemical forces). Concerning the degeneration of the diabase rock at Medford, Mass., Dr. Merrill* says: "In this case, as in that of the granite from the District of Columbia, we have to do with only the earlier stages of degeneration, with conditions which are as much in the nature of mechanical disintegration as of chemical decomposition."

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*Merrill, G. P., Rocks, Rock-Weathering and Soils, N. Y. 1897, p. 222.

With reference to the District granites Prof. Merrill[*] further says: "Aside from its state of disintegration the newly-formed soil differs from the massive rock mainly in that its feldspathic and other silicate constituents have undergone a certain amount of hydration." A mechanical analysis of the residual sand from these rocks shows no clay, but the smallest grade material found was silt with a diameter in millemeters of 0.10[†], of which there was 4.25 per cent present, corresponding in the above table to grade 6, and there listed as very fine sand.

In the case of a micaceous gneiss from Albemarle county, Virginia, Dr. Merrill[‡] found a total loss based on chemical analyses of the entire rock, of 44.67 per cent, corresponding to 35.73 per cent of clay on mechanical analyses, in the decayed portion of rock. Clearly, this represents a case chiefly of chemical decomposition.

The difference as brought out by the results in the case of the adjacent dikes of the Virginia diabase for the same locality is believed to be essentially one of difference in degree of decay. In each case the iron is the constant factor, and the Al_2O_3 indicates a loss, with approximately the same proportional loss for the other constituents. In the case of the total loss for the entire rock 70.31%, the final limit had been approximately reached, where all of the iron had, in the presence of an abundant supply of oxygen, become completely oxidized, and, therefore, retained at the expense of a proportionate loss in the remaining prominent constituents; while this limit has not been so nearly reached in case of the adjacent dike where the total loss amounts to only 37.10 per cent. This is made the more significant when the difference in the iron and alumina contents for the fresh and decomposed rock in the two cases is noted.

	Fresh rock		Soil	
	I[§]	II	I[§]	II
Al_2O_3	13.48	23.58	13.19	32.05
Fe_2O_3	11.60	6.85	35.69	9.83

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[*] Loc. cit.

[†] Bulletin U. S. G. S. 1898, No. 150, p. 378.

[‡] Merrill, G. P., Bull. Geol. Soc. Am. 1897, 8, 159, 160.

[§] Olivine diabase. Loc. cit.

The difference in oxidation for the two rocks is made apparent from the microscopic examination; chemical analyses; physical condition, megascopically and by the Fe_2O_3 constant factor, which was obtained directly from the chemical analyses and served as the basis for calculations in the other constituents lost and gained.

A DRAINAGE PECULIARITY IN ANDROSCOGGIN COUNTY, MAINE.

By H. T. Burr, Cambridge, Mass.

The drainage of the state of Maine is much impeded by the accumulation of glacial material in the valleys. Rivers are turned from their beds, and forced to struggle haltingly along in new and much obstructed channels. The waters are dammed back to form numberless lakes, which find outlet across the obstruction or, as sometimes happens, across a low divide to a valley beyond.

A chain of such lakes empties into the Androscoggin river near North Leeds, Androscoggin county. The lakes occupy a well marked north and south valley, which is generally parallel to the course of the Androscoggin. From the southernmost of the chain, lake Androscoggin, the waters find their way across the divide and into the Androscoggin river. The cause of this diversion is plainly to be seen in the irregular piles of glacial material heaped up across the valley in the vicinity of Leeds Centre.

The valley of the Androscoggin river is likewise much clogged with drift. Thus it happens that the waters from the lake do not find an easy path toward the river, but are turned backward against the natural slope of the country, and finally join the main stream four miles north of the point where they leave the lake. Throughout the course of this outlet stream there is not a single ledge, nor a foot of rough water under normal conditions. So quietly does it flow that it is known as the Dead river. The fall between the lakes and the Androscoggin river must be very slight.

This relation has led to consequences that appear to be unique. The river gathers its waters from numberless branches, reaching into the heart of the mountain regions of New Hampshire and Maine. In the spring, when the snows are melting, a vast body of water pours off the hills and the river becomes a fierce flood. The adjacent valley does not gather such a volume and its flood is restrained in the lakes and ponds. Thus it comes about that the river rises very rapidly, the lake slowly. Finally the slight difference between lake and river level is overcome and a great flood of muddy water pours into the lake. Then the lake rises equally with the river till the flood has reached its hight. With its waning the waters follow the sinking level of the river till the normal condition is resumed.

So fierce is this reversed current that it has frequently swept away strong bridges and borne them toward the lake.. The volume which rushes in, added to that which enters the lake at its head is sufficient to raise the lake about eighteen feet above its normal low-water level. So delicate is the adjustment that the opening of the dams at the Rangeleys, near the head of the Androscoggin, is sufficient to reverse the current in the Dead river and to raise the lake level many feet, even when conditions are otherwise normal.

It is evident that such a flood of muddy water entering a basin, for the moment wholly inclosed, must leave behind a great mass of sediment. This sediment is not spread widely over the floor of the lake, for the greater part of the bottom is remarkably free from mud. Moreover it is noted that the muddy waters do not spread out above the clear water, nor mix with them, but rather appear to displace them near the point of in-rush. Thus the sediment is concentrated there. In consequence of this a well developed delta has pushed its way into the lake, having all the normal characteristics. The stream winds along between low flat mud banks which stretch away on either side till they pass into shoals beneath the water. At present the water finds its way out through two distributaries extending backward, while the former course of a third is well marked by a succession of pond-holes now partially filled up. With every flood the waters spread out over the surface and lay down a new layer. If, as sometimes happens, the Rangeley dams are opened after the grass is well grown upon the meadows of the delta, the grit collects upon the blades in sufficient amount to play havoc with the farmers' scythes.

It appears from inquiry that the delta has changed noticeably within the last century. There is now firm ground where once there were pond-holes, while in sheltered places the delta has pushed its way farther into the lake. When dams were built in the Rangeley lakes, the volume of water in time of flood was somewhat decreased. Thus the current at such times is somewhat less powerful and as a result the flood does not hold its velocity so far into the lake. The channels, which are said to have been once very strongly marked in the muddy shoals beyond the delta front, have become much less distinct, while the whole bottom in the vicinity of the delta has been silted up till it is very shallow.

Already a large area, perhaps several square miles, has been taken from the lake through the building forward of this delta. The encroachment will go on till the Androscoggin has cut so deep that its flood cannot rise to the lake's level. It is even conceivable that, before that time shall come, the lake will be completely filled, and there will be a river flowing through a plain of which the materials have been largely brought from down-stream.

Aside from the interest which attaches to this unique delta in itself, this offers a striking illustration of the well-known fact that the work of land sculpture is largely done in time of flood. The transportation of this mass of material is the work of a few days. Almost the whole of the water which has borne the load from the river must pass out by the same way. A volume vastly greater finds its way out through the same channel during the time of normal conditions. Yet the work done by this great mass of out-flowing waters during all the rest of the year cannot undo, or even greatly modify, the work of the flood done in a few days.

A NOTABLE RIDE.

From Driftless Area to Iowan Drift.

By Samuel Calvin, Iowa City, Iowa.

There is in eastern Iowa one short journey which shows a more interesting variety of land forms in small space than can be seen almost anywhere else. It shows too, in a typical way, the different surface aspects of areas belonging respectively to the driftless area and to the plains of Kansas and Iowan drift. For these reasons the journey referred to should become famous, and might well become a standard in certain particulars, among students of Pleistocene deposits and topographic forms. The journey is over the Illinois Central railroad, it begins at Dubuque, and it may end at Dyersville. The whole distance does not exceed thirty miles.

At Dubuque the topography is that of the driftless area, and the topographic forms are determined by the effects of erosion on the massive, dolomitic, cliff-forming Galena limestone. In and around the city the Galena has been sculptured by atmospheric and other agencies into numerous picturesque towers and castles and mural precipices ranging from fifty to two hundred feet in hight. There are bold salients standing out prominently, like jutting headlands, between the lateral gorges cut in the Mississippi bluffs, and residences perched airily on their summits seem at first sight to be altogether inaccessible. Deep lateral valleys and ravines afford the only practicable routes for highways of every sort leading to the higher levels west of the city; and all these, for some distance, follow tortuous courses and ascend at very steep grades. The railway uses the valley of Catfish creek as the sinuous pathway whereby it is enabled to make the four hundred feet of ascent necessary to reach the upland plain at Peosta. From Dubuque almost to Julien the fantastically weathered crags and castles of Galena limestone, and the steep-sided hills littered with loose fragments of the dolomyte partially embedded in the thin, residual soil, are prominent features of the landscape, and at the same time are easily understood characteristics of the driftless area topography. The "Three Towers," massive columns of dolomyte forty to fifty feet in hight, rising from the comparatively level bottom of the stream valley, are seen a short distance west of Rockdale; and in the same neighborhood are many picturesque escarpments and buttressed walls and bastioned fortresses, carved by natural processes from the living rock, and lending charm and variety to this unique driftless landscape so strangely set in the midst of the great prairie plains of the middle west.

Before reaching Julien, the surface inequalities become toned down to a marked extent. The relief is very much less. The outlines of the hills are more flowing, the curves more gentle. The weather-beaten crags disappear. The surface is yet rolling and irregular as compared with the ordinary prairie; but the land is susceptible of cultivation to a greater or less extent, and most of it has been brought under the plough. The ascending grade of the small valley followed by the railway brings the surface here above the upper limit of the Galena limestone, up to the softer Maquoketa shales; and it is this shale formation that expresses itself in the cliffless, cragless, softened landscape. The billowy surface bears little resemblance, however, to even an eroded drift plain. There is a certain tumultousness and confusion manifest in the swells which mark the surface. There is no common level to which their summits rise; but a knob here and a ridge there may stand conspicuously above all the rest, and it is impossible to pick out any set or series anywhere, which can be referred to a common plane. The valleys of the larger streams are cut well below the general level of the region, the process of peneplanation is yet far from being complete, and the confused appearance of the land swells is due to the fact that the various parts of the surface are not being degraded at the same rate.

A few miles west of Julien, and sweeping around in a long prominent ridge a mile or two south of the railway line, are the abrupt slopes and cliffs of the Niagara limestone which overlies the Maquoketa shales. The Niagara, like the Galena, is dolomitic. It resists weathering and forms mural cliffs only slightly less pronounced than those of the older and more perfectly crystalline dolomyte already noticed. The total thickness of the Maquoketa formation is something more than two hundred feet, but the area in which the shales are superficial—the area between the outcrops of the upper beds of the Galena and the base of the Niagara cliffs—is comparatively narrow, rarely exceeding three miles in this part of Dubuque county. All around the foot of the Niagara escarpment the surface of the Maquoketa area presents a series of long, rain-sculptured, cultivated slopes, rather steep, but gradually blending into the more level area encountered after passing from the rugged topography of the Galena limestone to the more softened forms of the Maquoketa, near Julien.

A mile or two east of Peosta, the deep trenches and steep scarps charactertistic of the margin of the Niagara limestone are encountered. Erosion has here produced picturesque effects, not so pronounced maybe, but yet in a measure comparable with those seen in the region occupied by the Galena limestone. The base of the Niagara is somewhat softer than the Galena. Not far above the base are rapidly weathering beds containing a large amount of chert. As a result of differences in structure there are fewer vertical precipices in the Niagara than in the Galena area, and this is particularly true when the cliffs are formed by erosion of trenches in the basal portions of the Niagara formation. Talus material accumulates at the foot of the scarps, and the upper part of the cliff faces recedes as an effect of weathering. While the resulting slopes, as a rule, are not vertical, they yet stand at high angles; and so the transition from the area of Maquoketa shales to that of the Niagara, is marked by an abrupt and steep ascent of sixty to a hundred feet. This sharply defined offset is one of the most striking topographic features in this part of the driftless area.

On the line followed by the Illinois Central railroad the edge of the Niagara does not extend far beyond the margin of the Kansan drift; but south of the valley of Catfish creek, and conspicuous even from the car window, the Niagara gives character to a high ridge, noted above, which extends two or three miles into the driftless area; and at Sherrill's Mound, in the northern part of the county, the Niagara escarpment is nearly ten miles east of the edge of the drift. The drift-covered area is entered by the railway line less than a mile east of Peosta. A cut, thirty to forty feet in depth, is made in the thickened margin of the Kansan till one-half mile east of the village named; and at the station the traveler has at last an uninterrupted view to the western horizon. He has reached the upland plain, a plain which varies but little in altitude all the rest of the way across the state. He has passed from the driftless area where the topographic forms are the resultant of erosion acting on indurated rocks of varying degrees of hardness, to an area of comparatively inconspicuous topographic forms developed by erosion of a body of drift which was originally left by the retreating ice fields, with a surface approximating a plane. It was not a true plane, however, but a drift plain, diversified by numerous undulations which were due to two facts —the ice deposited more material in some places than in others, and the mantle of glacial detritus was not in all cases sufficient completely to disguise the high ridges and the deep valleys of the preglacial topography. The thickening of the Kansan drift along its ultimate border has given rise to a well marked ridge which curves so as to trend northeast and southeast from Peosta. The drift plain is inclined very gently to the west, and all the drainage streams, for some miles back from the drift border, take a westerly or southwesterly course. A new type of topography now engages the attention of the observer. The landscape stretches away in an unbroken plain to the far horizon; but the surface of the plain, as in all the Kansan-drift areas of Iowa, is carved into a dendritic system of miniature hills and valleys. Compared with the driftless area which was traversed only a mile or two east of Peosta, the visible effects of erosion are very small. Except along the permanent streams the rain sculpture has affected only the drift; it has not exposed any of the indurated rocks. Making allowance for the original undulations of the plain, it may be said that the symmetrically rounded swells of the surface, in striking contrast with the tumultuous and disorderly arrangement seen in the area of eroded Maquoketa shales, all rise approximately to the same level. The Kansan drift in this region is everywhere overlain by loess. Mature erosional topography, on a small scale, was developed on the Kansan surface before the loess was laid down upon it. Subsequent erosion of the friable loess has modified the curves of the original profile lines to some extent, and so the surface features which present themselves between Peosta and Epworth, the next station west, have been classified under the name of loess-Kansan topography. The region affords as typical examples of this kind of surface carving as can be found scores, or even hundreds, of miles kack from the terminal margin of the Kansan ice.

The normal loess-Kansan surface, as seen between Peosta and Epworth, is modified by a number of pahoid ridges between Epworth and Farley; but west of the station at Farley, the railway enters immediately upon a new type of topography, upon a plain of Iowan drift. The Iowan is much younger than the Kansan. Its surface is nearly level; it is absolutely uneroded; it is not covered with loess; and large granite bowlders, projecting conspicuously above the surface, catch the attention and awaken the interest of even the unscientific traveler. It is a narrow lobe of Iowan drift which is traversed by the railway between Farley and Dyersville. The lobe occupies a low plain as if the Iowan ice had flowed out in a long tongue between ridges of eroded Kansan. These rain-sculptured ridges, now covered with loess, are recognizable on either hand from the platform of the coach. The level, uneroded Iowan surface afforded the engineer in charge of the location of the railway line an opportunity of which he was quick to take advantage. This narrow Iowan lobe between Farley and Dyersville, is as typically Iowan as any area in the state; but west of Dyersville, if the observer wishes to pursue the subject further he may enter upon the great Iowan plain; and all the way across the counties of Delaware, Buchanan, Black Hawk, and westward to the Wisconsin moraine in Hardin, he will find his whole horizon occupied by a surface showing only the gentle undulations left by the melting Iowan ice. Erosion has played no part in producing the land forms which characterize ninety-nine per cent of the Iowan area. Except in the immediate neighborhood of the streams the topography is constructional.

Twice in the short journey from Dubuque to Dyersville, the land forms change with almost surprising suddenness; three distinct topographic areas are included between the eastern and western borders of a single county.

A POSSIBLY DRIFTLESS AREA IN NORTHEASTERN MINNESOTA.

By U. S. GRANT, Northwestern University, Evanston, Ill.

In the reports of field work by the Geological and Natural History Survey of Minnesota mention has been made of an area, in the northeastern part of the state, in which the glacial drift is scant or lacking, and which possesses some of the other distinctive characters of non-glaciated districts.* Because the chief object of this field work was the investigation of the crystalline and associated rocks, this area—in common with other areas and questions of interest from a glacial standpoint—was not studied in detail. Moreover, as it lies well within a region which is underlain by a monotonous mass of gabbro (the great Keweenawan gabbro mass), it was not visited except in a few points. Still, sufficient is known to demonstrate that this area is an anomalous one, and that it has exceptional features when compared with the immediately adjacent country which is markedly glaciated and more or less drift-covered.

The area under consideration is situated in the northeastern part of Lake county, thirty-five miles north of lake Superior. As far as known it is somewhat elliptical in outline, the major axis, which runs northeast and southwest, being twelve miles in length and the minor axis eight miles. The surface is undulating with elevations that usually rise no more than thirty feet above the general level. In common with the surrounding glaciated country this area has many small lakes and the drainage system is very recent and poorly developed. In fact the topographic features are very similar to, or identical with, those of much of the gabbro-covered district of northeastern Minnesota. This underlying rock is a coarse grained aggregate of plagioclase (near labradorite), augite (diallage), olivine and magnetite (titaniferous). The plagioclase is the most abundant mineral and at times so predominates over the others that the rock may be termed an anorthosyte.

Lying within the area described are three lakes—Wilder, Alice and Polly†—of larger size than the majority of those in the vicinity. It was about the shores of these lakes that most of the details given below were observed. The description of the phenomena about Wilder lake is from the notes of N. H. Winchell* and the phenomena here are characteristic of the whole area.

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*N. H. WINCHELL: Geol. and Nat. Hist. Survey of Minn., 15th Ann. Rept., p. 350, 1887. U. S. GRANT: Ibid., Final Rept., vol. 4, pp. 421, 437, 1899.

†The locations of these lakes can be seen by consulting late 68, or plates 79 and 80, of vol. 4 of the Final Rept. of the Geol. and Nat. Hist. Survey of Minn.

At Wilder lake there is no visible drift, or nearly none, except such as is referable to the gabbro. There are fine exhibitions of the process of making boulders of disintegration, some bluffs being in the process of decay but retaining undecayed, rounded, boulder-like masses from two to six feet in diameter, the surrounding rock being so rotted that it can be picked to pieces by the fingers. There is no show of ice action, and the rock everywhere is superficially crumbling. There is not a total absence of transported drift, but only very rarely a boulder of granite which also shows the disintegrating action of age. The gabbro bluffs do not look clean and smooth cut, but are falling down in situ, the joints being worn out so as to produce little channels in which water runs down to the lake. Old weathered surfaces are pitted with holes of all sizes up to those of a hen's egg. On the tops of the hills is a thin, often gravelly, soil produced by the decay of the gabbro. The whole of Wilder lake, from its eastern to its western end, has these characters. Throughout this distance, although the rocks are bare much of the way along the shores, not a glacial scratch nor a glaciated surface could be seen, although special notice was given to this feature. At the west end of the lake, in section 33, T. 63-8 W., one apparently moutonnéed surface was seen, but it had no striæ. In passing further west the rocks assume a more preserved condition and occasionally a rounded surface appears, and at the entrance to the main Kawishiwi river in the southern part of section 30, T. 63-8 W., are glacial striæ. Still further west such surfaces are more and more common, and finally every surface facing toward the north is striated, and all the rock is hard and fresh.

In making a section from north to south through the area in question the following facts were noted. On the portage, between a pond near the northeast corner of section 20, T. 64-6 W., and the lake in the southern half of the same section, are many outcrops of gabbro much decayed, and in places there is considerable residual soil. Very few fresh rock surfaces were seen. No large foreign boulders were noted, but there are a very few small boulders of slate and granite, usually under eight inches in diameter. Aside from these boulders no drift was noted. This lake is surrounded by gabbro hills, all decaying into soil. The shores of the lake in section 32, T. 64-6 W., also show many outcrops of decaying rock. Between the last mentioned lake and the Kawishiwi river, in section 5, T. 63-6 W., the gabbro is commonly very much disintegrated and practically no foreign boulders were seen. On the south and west shores of this river in sections 4 and 5, T. 63-6 W., the same rock decay is very marked and boulders of disintegration are forming. On lake Polly the gabbro, while showing some signs of decay, is not nearly as much decayed as in the localities to the north just mentioned, and near the southeast side of this lake the usual glaciated and more or less drift-covered district is encountered.

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*Loc. cit.

On the Kawishiwi river in sections 21, 16, 17, 8 and 7, T. 63-6 W., especially in the last two sections, the rock is much disintegrated. Only a few small foreign boulders occur. One noticeable feature is the presence of a few bosses of smooth, fresh gabbro within a few yards of other bosses which are much decayed. These smooth bosses show no glacial striæ. The same character of country as above described is seen about lake Alice, but on the portage northward from this lake to Thomas lake the gabbro is not particularly decayed and drift is present in considerable quantity.

From the above descriptions it is evident that the area under discussion is in some respects markedly different from the surrounding country. These differences may be included under three heads:

First: The absence, except for a very few, small, foreign boulders, of glacial deposits. These boulders might have been brought in by floating ice. The surrounding country shows abundant evidences of glacial drift, although in many localities the thickness of the drift is slight. But even in such places and on bare glaciated knobs foreign boulders are numerous and not infrequently of considerable size.

Second: Glacial striæ are absent. Outside of this area they are reasonably plentiful. The general direction of striæ in this vicinity is south-southwest. Some fifteen miles to the east the direction is south. Roches mountonnées are abundant in the surrounding district, but in the limited area under discussion such forms are not evident, although some of the rounded bosses of fresh rock may be of this nature. Still they do not show glacial striæ as do similar forms elswhere.

Third: The country rock is decaying and from it boulders of disintegration and soil are forming. This rock disintegration is the prominent feature which obtrudes itself upon the notice of one entering this area. In the surrounding country weathered rock is unknown, having been removed by glacial action; postglacial weathering extends only a small fraction of an inch below the surface; and there is no residual soil.

The disintegrated rock and the consequent absence of glacial striæ might possibly be due to postglacial weathering, but this would not account for the absence of drift. There is, however, no reason to refer this decay to postglacial weathering. The underlying rock is identical with that in the immediately adjacent district which is not weathered, and the difference in present condition is not referable to original differences in the country rock. The decay is not postglacial, but preglacial or possibly interglacial. It is evident that the area under consideration was not subjected to the action of moving ice, at least during the last glacial advance.

The cause of this is not so evident, but a probable explanation is to be found by assuming that this area was covered by a mass of stagnant ice over which the general ice advance took place. The area, while not a marked valley, still is lower than any district of corresponding size in the adjacent country, except on the southwest where the altitude is less. Three miles to the north of the eastern part of this area is a prominent ridge rising 200 to 450 feet above the general surface and trending east and west. Five miles to the south is another higher ridge running northeast and southwest. In the general southerly advance of the ice a stagnant mass very probably was formed on the lee side of the first mentioned ridge or between the two ridges. There is, however, evidence of moving ice on both sides of this area but within the district included between these two ridges, showing that a mass of stagnant ice did not completely occupy the low land between the ridges. With this explanation of the phenomena observed there is still the anomalous fact that in its retreat the ice left practically no deposits on the area in question, while in all the surrounding district evidences of glacial deposits are abundant, even though the thickness of these deposits is frequently slight.

This area is several miles without (north of) the recognized limit of the Lake Superior ice lobe, and it seems hardly possible to account for its peculiar features as due to interlobal conditions. Nor is the idea of a driftless area so far removed from the southern limit of glacial action one which seems probable, although the driftless region of southwestern Wisconsin is far within the drift boundary. But when the small size of the area under discussion and the thickness of the ice in the surrounding region are considered, the improbability, if not the impossibility, of this area having remained free from ice becomes apparent. The highest hills, some 500 feet above the general level, are glaciated to their tops and there are excellent reasons for believing that the ice rose far above these hills. With such conditions it is, to say the least, very improbable that a small area only twelve miles long and eight miles wide should not have been covered with ice.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Some Glacial Wash-Plains of Southern New England. By J. B. WOODWORTH. (From the Bulletin of the Essex Institute, Salem, Mass., vol. xxix, pp. 71-119, with six sketch maps and a section; published July, 1899.)

After the description of wash-plains formed in front of existing glaciers, the general characters and classification of the stratified drift deposits of the continental ice-sheet are stated. From their relation to the ice-margin at the time of their formation, four classes of these deposits are recognized: 1. Frontal moraine terraces, with an ice-contact slope, charged with till and boulders, a true morainal deposit; 2. Frontal terraces, like the preceding but lacking the till-coating along the ice contact; 3. Esker-fans, small plains of gravel and sand built at the mouth of subglacial tunnels and channels in the ice, associated with an esker or esker-like chain of deposits made within the area of the ice-sheet at the same time; 4. Wash-cones, steeply sloping deposits, with ice-contact slope on the iceward side culminating in a high point, with gentler slope outward, in the manner of alluvial cones.

The broad glacial wash-plains of gravel and sand descending from the terminal moraines of Martha's Vineyard, Nantucket, and Cape Cod, are the most extensive found in Massachusetts. About halfway between the base of Cape Cod and Boston, Mr. Woodworth maps a series of morainal tracts and comparatively small wash-plains, extending from the vicinity of Providence, R. I., northeastward to Bridgewater and Scituate, Mass., which doubtless marks a line of boundary of the ice-sheet at a stage of its general retreat. Another series of similar character, lying about fifteen miles farther northeast, extends from Woonsocket, R. I., to Canton, Mass.

Mr. Woodworth shows that the marginal part of the ice-sheet during its recession from southern New England, at least as far north as to the Cape Ann boulder moraine, had sufficient thickness and slope to be in motion quite to its boundary. Masses of the ice-sheet, however, were left in many places by its retreating border, and became partly or wholly inclosed by plains of stratified drift, their places being now occupied by lakes. W. U.

The Mechanical Composition of Wind Deposits. By JOHAN AUGUST UDDEN. Augustana Library Publications, No. 1; 69 pages, with 38 tabular figures. Rock Island, Ill., 1898.

In this memoir Prof. Udden describes the wind erosion and transportation of fine lag gravel, drifting sand, finer lee sand, and atmospheric dust, as observed at many localities from Florida, Maryland, and Massachusetts, west to Arizona, Colorado, and Washington. It is believed that this investigation will help to answer the question of the origin and mode of deposition of the loess. The author, however, concludes that the geologic action of the wind is yet too imperfectly known to permit a final verdict concerning its share in the origin of this formation. W. U.

The Upper Cambrian Faunas of Mt. Stephen, British Columbia; The Trilobites and Worms. By G. F. MATTHEW. (Trans. Roy. Soc. Can., Ser. 2, vol. 5, sec. 4, p. 39.)

This is a critical review of the genera and species of this interesting fauna, first made known by Dr. Carl Roeminger. The fine preservation of these fossils makes them available for comparison to an unusual degree.

Only the trilobites and worms are described in this paper. Among the latter are included the Hyolithidæ heretofore classed as pteropods. The author in a companion article (The Etcheminian Fauna of Smith Sound, New Foundland) gives his reasons for offering the Annelida as a suitable place for classifying the Hyolithidæ and related forms: chiefly on account of the slender cylindrical terete tube from which they spring.

The new genus Urotheca is proposed for chitinous or horny flexuous tubes having some of the characters of Hyolithes. For another type of these tubes the genus Byronia is proposed; these are annulated like Tentaculites, but are larger and flexuous.

The following genera of trilobites are recognized: Ogygia (Ogygopsis) Bathyuriscus, Zacanthoides, Neolenus (n. gen) Ptychoparia, Dorypyge, Agnostus, Corynexochus, Dolichometopus, Oryctocephalus and Conocephalites. On a review of these genera, and their geological range the author expresses the opinion that the fauna of Mt. Stephen cannot be older than the Peltura fauna of Europe.

At page 64, an interesting table is given showing the gradual reduction in the number of the body rings, etc., of the trilobites during the progress of the Cambrian age; and also the growth of the pygidium at the expense of the thorax.

Studies on Cambrian Faunas, No. 4; Fragments of the Cambrian Faunas of New Foundland. (Trans. Royal Soc. Can., Ser. 2, vol. 5, sec. iv, p. 67.)

The fossils described herein are chiefly from the Paradoxides and Protolenus zones. From the latter a number of new species are described, and several species of the former zone are discussed. The species Conocoryphe trilineatus is recognized, and supposed to be from the beds carrying Paradoxides davidis. Erinnys venulosa Salt, is reported from the same beds, and is referred to Harpides breviceps Ang., but Salter's generic name is retained for it. A large Paradoxides like trilobite is referred to the Sardinian genus Metadoxides, Bornemann.

A third article on the Etcheminean fauna of Smith sound, New Foundland, has already been reviewed in this journal.

There are eight plates of figures of the different species described in these articles.

MONTHLY AUTHORS' CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Ashley, Geo. H.

The coal deposits of Indiana. (23d Ann. Rep., Dept. Geol. & Nat. Resources, pp. 1565, 7 geol. maps, 90 sketch maps, and numerous plates and figures.)

Bennett, L. F.

Notes on the eastern escarpment of the Knobstone formation. (Proc. Ind. Acad. Sci., 1898, pp. 283-288.)

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*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Blatchley, W. S.

Twenty-third annual report. Department of Geology and Natural Resources [Indiana], pp. 1741, 93 plates, maps and sections; Indianapolis, 1899.

Buckley, E. R.

On the Building and Ornamental stones of Wisconsin, Bull. No. 4, Economic series No. 2, Wis. Geol. & Nat. Hist. Sur., pp. xxvi and 544. 69 plates. Madison, 1898.

Chamberlin, T. C.

An attempt to frame a working hypothesis of the cause of glacial periods on an atmospheric basis. (Jour. Geol., Sept.-Oct., 1899, pp. 545-585.)

Coleman, A. P.

A new analcite rock from Lake Superior. (Jour. Geol. Vol. 7, pp. 431-437, July-Aug., 1899.)

Coleman, A. P.

Corundiferous nepheline syenite from eastern Ontario. (Jour. Geol. Vol. 7, pp. 437-445, July-Aug., 1899.)

Dennis, D. W.

An old shoreline. (Proc. Ind. Acad. Sci., 1898, p. 288.)

Dennis, D. W.

Two cases of variation of species with horizon. (Proc. Ind. Acad. Sci., 1898, p. 288.)

Dryer, Chas. R.

Jug rock. (Proc. Ind. Acad. Sci., 1898, pp. 268-269.)

Dryer, Chas. R.

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CORRESPONDENCE.

On Some Fragments of Slate Found Floating on the Sea in Southwest Patagonia.*

By Erland Nordenskjold.

During our stay, in the latter part of the month of April, 1899, on a branch of Ultima Esperanza, a channel extending far inland from the Pacific ocean in southwest Patagonia, Dr. O. Borge and the author made the following remarkable observation.

While out on row-boat trips for collecting planktons and for fishing, we saw floating on the water, which was quiet or only very gently disturbed, small pieces of slate gathered into rafts of varying sizes. They were driven to and fro near the edge of the water, until carried away by a strong current which now and then came close to the shore. What great quantities of these rock fragments floated about can be readily appreciated from the fact that in skimming the surface with nets for only two or three minutes 700 pieces were taken in.

The rock fragments had evidently been floated out from the shores. for the beach gravel consisted in the main of the same kind of material, washed down as a disintegration product from the steep and thoroughly weathered beach wall that consisted of a bituminous slate of Mesozoic age.

On being touched the fragments would sink, becoming wet on their upper surface, where they otherwise were dry while floating. The same evidently happens when the water is perturbed by strong wind. In this manner a considerable quantity of the disintegrated product in the talus of the sea cliffs must be transported in this place. Great numbers of rock fragments float out from the shore, either to land on the shore again or later to sink in the water at varying depths, where thus a peculiar deposit will be formed consisting of pieces of Mesozoic slate mingled with the remains of plants and animals of the present age.

Besides the slate, floating particles of feldspar were also noticed. The pieces of slate have a specific gravity of 2.71. The specific gravity of the water in the channel is 1.0049 (15°). The largest fragment which I collected by skimming weighed 0.8 grams. Twenty of the smaller pieces had an average weight of 0.3 grams. The slate contains only a small amount of bituminous material and includes no vesicles of any kind. It must hence be distinguished from vesicular slag which often is to be found floating on the sea on our coasts.

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*Under the above title an interesting account is given in Geologiska Föreningens i Stockholm Förhandlingar for May this year, of a phenomenon akin to, if not identical with, that described by professor F. W. Simonds in the January number of the Geologist for 1896, under the heading Floating Sand: An Unusual Mode of River Transportation. Believing that Nordenskjöld's account will interest the geologists of this country, I herewith present it in translation from the Swedish, leaving out references to a figure which accompanies the original and which shows a small collection of the floating bodies. J. A. Udden.

How do these rock fragments float in spite of the fact that they weigh as much as 0.8 grams a piece and have a specific gravity of nearly three times that of the water?

In seeking an answer to this question the following facts are of importance. I noticed that small gaseous bubbles adhered to the under side of the fragments. On some of the fragments on shore I saw a loose coating of these bubbles. At the very edge of the water there were to be seen also fragments that evidently had just begun to float and were lifted by the gentle swell of the water, bouyed up by the bubbles, then to be caught by the current and to be carried away or again tossed on shore. With ebb and flood the shore line is kept moving and a greater number of fragments are thus given a chance to be launched on the water. I regret having been prevented from undertaking a more thorough investigation of all the conditions connected with the phenomenon, being occupied with other work. Nor had I the apparatus needed to collect samples of the gas which gathered under the fragments.

It appears probable that the floating chips were provided not only with the large gas bubbles that were apparent to the unaided eye, but that they were really covered with a continuous film of gas. Such a film should prevent the water from adhering to the slate, and thus keep the latter afloat, as it would, so to speak, curve up from under the edge of the chip and cause the weight of the volume of water displaced to equal, or exceed, that of the rock fragment itself. Vegetable matter may also, to a certain extent, prevent the adhesion of water. A small quantity of diatoms and other algous remains may yet be found adhering to the material.

Singular as may appear the observations here related, I suppose we saw in this case a phenomenon, which may be quite common in places favorably situated on the seashore. Geologically, it may have a greater significance than one is inclined to ascribe to it at first sight.

Some Cretaceous Drift Pebbles in Northern Iowa.

As bearing on the question of the probable extent of distribution of the Cretaceous deposits under the drift in Minnesota, it may be worth the while to note the occurrence of Cretaceous materials in the drift at more southern places. On this I happened to make some observations in eastern Iowa last summer. In the course of a study of different phases of the drift in Scott, Muscatine, Louisa, and Lee counties, I had occasion to examine closely several thousands of pebbles taken at more than half a hundred different localities. One pebble in about each thousand in what is known as the Kansan drift consists of a gray calcareous soft shale containing Globigerina, Textularia, and cycloid fish scales. I have found these pebbles in each of the counties mentioned. They seem to be generally present. From my experience this summer I would infer that in a lot of 1,000 pebbles collected promiscuously from a fresh and unweathered exposure anywhere in this region there would be one or more pebbles of this kind.

It does not seem likely that these pebbles can have come from the Colorado formation in the western part of Iowa. This would necessitate an extended transportation too nearly from west to east to have taken place in the Kansan ice field. On the other hand, these fragments of shale seem too soft and too frequent of occurrence to be regarded as a residue of material picked up from the Cretaceous in the extreme northwest and they appear too widely and too uniformly distributed to be derived from any concealed outlier in the region here.

In this same drift I have also found broken crystals of staurolite, which Dr. C. P. Berkey regards as similar in appearance to crystals of the same mineral occurring in abundance in metamorphic rocks in the Little Falls district and in northern Minnesota. One of these crystals was found in Scott county, one near Fruitland in Muscatine county, and one twenty miles west from the latter place. In general the pebbles of this drift indicate a transportation from the north, with a local deflection to the southeast.

J. A. UDDEN.

PERSONAL AND SCIENTIFIC NEWS.

DR. MARCUS BENJAMIN IS GIVING in "Science" a series of biographical sketches of past presidents of the American Association for the Advancement of Science, with occasional portraits. The issue for November 19th has an excellent portrait of John W. Foster, with sketches of Foster, Hunt, Smith and others not known as geologists.

MR. W. H. DALL has recently returned to Washington, after an absence of several months on the Pacific ocean during which he has travelled some 23,000 miles.

MR. C. E. SIEBENTHAL, formerly of the University of Chicago and now of the Manual Training high school at Indianapolis, has completed, and is able to furnish copies of, a relief model of Chicago and vicinity. This model brings out clearly the contrast between the topography of a drift-covered country within and without an old lake bed, and the former shore lines about the southwestern end of lake Michigan are also shown.

DR. A. C. SPENCER of the U. S. Geological Survey spent the last six weeks of the field season on reconnoisance work in southwestern Colorado. He has been tracing the Devonian of the region and rectifying the earlier mapping.

MR. J. W. FINCH, late fellow of the University of Chicago, is meeting with much success in his work as geologist of the Woods Investment Company, Victor, Colorado.

DR. A. G. LEONARD HAS CHARGE of the geological work at the State University of Missouri this year in the absence of professor Marbut.

PROF. KOTORA JIMBO, of the faculty of the Imperial University Tokyo, Japan, has issued a condensed English review of the minerals found in Japan, the number of species enumerated being 128. The order of listing and the treatment of the crystal faces are according to the system of Dana. The paper is printed in the Journal of the Science College of the Imperial University, vol. xi.

GEOLOGICAL SOCIETY OF WASHINGTON. The ninety-third meeting of this society was held on Wednesday evening, November 22d. The following papers were presented: "Structural features on the western margin of the Great Basin" by F. B. Weeks; "Preliminary notes on the Cape Nome gold district, Alaska" by F. C. Schrader; "The type section of the Pottsville formation" by David White; "The Roseburg folio" by J. S. Diller.

THE FOURTEENTH ANNUAL MEETING OF THE IOWA ACADEMY OF SCIENCE will be held at Des Moines, December 26 and 27th. As usual a number of geological papers will be presented. An evening lecture is being arranged for the 26th.

NATIONAL GEOGRAPHIC SOCIETY. Because of the press of his duties as hydrographer of the U. S. Geological Survey Mr. F. H. Newell has resigned the secretaryship of this society. Mr. Joseph Stanley Brown, editor of the bulletin of the Geological Survey of America, succeeds Mr. Newell as secretary.

THE DEPT. OF GEOLOGY AT CORNELL COLLEGE, IA., has been given larger space this year, and valuable additions have been made to its equipment. It now occupies the second floor of South Hall, including a lecture room, a large and well lighted laboratory, a map room, a private laboratory and office, and two store rooms. The equipment for physiographic work consists of about 1,000 topographic maps and charts and a number of relief maps and models. Of these may be mentioned the Harvard Geographical Models, and the relief maps of The Grand Canyon of the Colorado, Mt. Shasta, the Chattanooga District, and the large relief map of the United States, made by Howell, of Washington. Several hundred photographs and over 1000 lantern slides have been secured recently, and a McIntosh Biunial Stereopticon for projection by means of the lime light. In order to stimulate the awakening interest in physiographic studies in the highschools of Iowa, these slides are loaned to responsible teachers in the state on more liberal terms than are customary.

The department is provided with a Julian lathe of the College pattern, a petrological microscope, a small collection of microsections, an equipment for class work in blow pipe analysis of minerals, and photographic apparatus unexcelled in the perfection of its instruments.

The college museum supplies ample illustrative material from a collection of fossils estimated at 9,000 specimens, and one of rocks and minerals estimated at one-third of that number. The departmental library contains over 800 volumes.

The chair of geology at Cornell is held by professor W. H. Norton, and the department enrolls this term more than 90 students.

THE STUDENTS IN THE DIVISION OF GEOLOGY, Harvard University in the first year of research, form the assistants of a local survey under the direction of Dr. Jaggar. During the first half year the work is areal, plotted on maps to a scale of 1200 feet to the inch. The final report is in the form of a thesis, with maps and sections. In the second half-year the thesis springs from work upon a field problem, not areal, which may require study of large or small districts. In this the student is at liberty to avail himself of any previous knowledge possessed by co-workers or published in papers, and to visit any regions which may be important.

TWO OF THE SERIES OF LECTURES now being given in the Lowell Institute courses in Boston are "The Geology and Natural History of the Bermudas," by Prof. A. E. Verrill of Yale; and "The relation of the topographical features of the earth's surface to geological structure," by Prof. G. H. Barton of Mass. Inst. of Technology.

ACCORDING TO THE STATE MINING INSPECTOR OF MISSOURI (George E. Quinby) it is the opinion of Prof. W. P. Jenney, who spent several weeks in southwestern Missouri investigating the drill records and the development of deep drilling, that there exists, all through that district, in the sedimentary rocks, strata of zinc ore two hundred feet apart, below the 250-foot level, to a depth of more than a thousand feet below the surface.

DR. R. S. WOODWARD of Columbia College, read a paper at the late meeting of the National Academy of Sciences, giving some of the results of long investigation into the physics of the earth's atmosphere. He stated that the atmosphere extends, at the equator 26,000 miles beyond the earth, and 17,000 at the poles, thus taking a position intermediate between those who hold that it has no limit and those who consider that it reaches outward from the earth one or two hundred miles. He also showed that the prevalent notion as to the weight of the atmosphere, viz. that of a shell of mercury 30 inches in thickness surrounding the earth, is erroneous. He allowed the mass of the atmosphere to range between 1-1,200 and 1-10,000,000 of the mass of the earth.

WALKER PRIZES IN NATURAL HISTORY. The Boston Society of Natural History offers annually two prizes for memoirs on certain subjects selected by a committee of that society. The first prize is sixty dollars, which may be increased to one hundred dollars, and the second prize does not exceed fifty dollars. The competition for these prizes is not restricted, but is open to all. The memoirs presented in this competition are to be based on a considerable body of original and unpublished work, accompanied by a general review of the literature of the subjects. The subjects selected for 1900 are : "Stratigraphy and correlation of the sedimentary formations of any part of New England," and "A study in paleozoic stratigraphy and correlation." The memoirs must be in the hands of the secretary of the society on or before April 1, 1900. The subject for 1901 is "Monograph on any problem connected with or any group belonging to the North American fauna or flora." Further information concerning these prizes and rules to be observed in competing for them may be obtained from the secretary of the society, Mr. C. F. Batchelder.

PROF. CALVIN OF THE IOWA GEOLOGICAL SURVEY has presented his preliminary report upon the work of the year. The main energies of the survey have been directed as before to areal work though an increasing amount of subject work is being taken up. Professor Calvin devoted his attention to the Upper Coal Measures and older drift in Page county and with Mr. Bain completed the work in Dubuque county. Prof. W. H. Norton of Cornell College worked in Cedar and Bremer counties on problems connected with the Devonian and Silurian and the Iowan drift. Prof. J. A. Udden carried his work south as far as to cover Louisa county. He connected here with Mr. Savage who was making preliminary surveys in Henry county. In Marion county Prof. B. L. Miller of Penn College, filled in an important gap in the previous mapping. In the northwest professor Macbride continued his studies of the Wisconsin drift, covering Dickenson and Osceola counties and devoting especial attention to the lakes of the region. West of him Mr. F. A. Wilder, of Des Moines, connected his work with that already completed farther south by surveying Lyon and Sioux counties, devoting especial attention to the puzzling extra-Wisconsin drift of the region. In the north central portion of the state Mr. Ira Williams carried professor Calvin's

Cerro Gordo county work north so as to cover Worth county and Dr. S. W. Beyer finished his earlier work in Hardin county.

The subject work has consisted mainly of a very careful study of the paving brick clays of the state carried on by Dr. Beyer in behalf of the survey and in coöperation with the State College, State University, the Association of Brickmakers and the Iowa Engineering Society. This study, which will in time be extended to cover the whole subject of the local clays, is being made very exhaustive and will undoubtedly be of much economic value to the State. A preliminary report will be submitted this year. The lead and zinc fields near Dubuque are being studied in their economic aspects by Mr. Bain, and the reopening of mines and the building of a large concentrating mill has already resulted. Mr. Bain has also been collecting samples and making other studies relative to cement materials throughout the state. The samples are now in the hands of the chemist for analysis.

Within the year the ninth volume of the Survey reports has been printed and distributed and a special bulletin on the grasses of the state is now in press.

A PROPOSED INTERNATIONAL JOURNAL OF PETROLOGY. In the December number of the American Journal of Science Messrs. J. P. Iddings and L. V. Pirsson, American members of the committee for this proposed journal present the following statement:

> The committee appointed by the seventh International Congress of Geologists to consider plans for the establishment of an international journal of petrography has chosen Prof. F. Becke of Vienna, well known as editor of Tschernak's Mittheilungen, president of the committee, and has taken the first steps toward the organization of such a journal. It has been proposed that articles appearing in it shall be printed in French, German or English at the option of the author.
>
> While primarily intended for the publication of reviews and abstracts of all petrographical papers wherever published, it is suggested that it may include also articles which shall appear in it for the first time. The carrying out of this must depend on the financial support the journal receives.
>
> The journal is to be managed by a committee appointed by the International Congress of Geologists, the committee to select an editor who shall have two assistants; the editor and assistants to receive salaries for their services.
>
> The desirability of having one source, thoroughly up to date, to which to turn for information concerning all matters published on petrology is self-evident to all attempting to keep abreast with the rapid progress of this science. One has only to observe what a great impulse to the science of mineralogy has been given by the establishment of Groth's Zeitschrift für Krystallographie, to be convinced of the usefulness and convenience of such a journal.
>
> The necessity of forecasting as correctly as possible the financial support obtainable for such a journal has suggested to the American members of the committee the plan of calling attention to the enterprise and of inviting all interested in its success to communicate to

either of them such suggestions or information as may aid in estimating the amount of annual subscriptions or contributions that may be obtained from this country.

It is expected that the chief support will come from individual subscriptions and from university and public libraries, but it may be possible to obtain assistance, in the first years of the undertaking at least, from other sources.

GEOLOGICAL SOCIETY OF AMERICA. The twelfth winter meeting will be held in Washington December 27 to 30. The meetings are to be held in the lecture room of the Columbian University and the session opens at ten o'clock Wednesday morning, December 27. The hotel headquarters is the Wellington, adjoining the Columbian University, on Fifteenth street. Further information concerning the meeting may be obtained from the secretary, Prof. H. L. Fairchild, Rochester, N. Y. The preliminary list of papers to be presented at this meeting contains the following titles:

Physiographic development of the Washington region. N. H. Darton.

Physiographic terminology with special reference to land forms. W. M. Davis.

Erosion forms in the Harney Peak district, Black hills, South Dakota. Edmund Otis Hovey.

Camas land, a valley remnant. Geo. Otis Smith and Geo. Carroll Curtis.

Topographic features of Ohio. W. G. Tight.

Drainage modifications in southeastern Ohio. W. G. Tight.

Geological structure of Coffeyville (Kansas) gas field. G. Perry Grimsley.

Surface temperature of the earth. Alfred C. Lane.

The landslides of the Rico mountains, Colorado. Whitman Cross.

A recent fault scarp in the Lepini mountains, Italy. W. M. Davis.

Beach structures in Medina sandstone. H. L. Fairchild.

Glacial erosion in the Aar valley. Albert P. Brigham.

Movement of glaciers. Harry Fielding Reid.

Stratification and banded structure of glaciers. Harry Fielding Reid.

Glacial origin of the older Pleistocene in the Gay Head cliffs, with a note on the fossil horse of that section. J. B. Woodworth.

Post-glacial time in Huron county, Michigan. Alfred C. Lane.

Distinction between Upper and Lower Huronian. A. P. Coleman

Keewatin of eastern central Minnesota. C. W. Hall.

Keweenawan of eastern central Minnesota. C. W. Hall.

Geology of Quebec City and its environs. Henry M. Ami.

The Silurian-Devonian boundary in North America. Henry S. Williams.

Stratigraphy of the Pottsville series in Kentucky. Marius R. Campbell.

Vertebrate footprints in Carboniferous rocks of Wrentham, Mass J. B. Woodworth.

Relative ages of the Kanawha and Alleghany series as indicated by fossil plants. David White.

Newark formation of the Pomperaug valley, Connecticut. William Herbert Hobbs.

Jurassic rocks of S. E. Wyoming. Wilbur C. Knight.

Mesozoic stratigraphy of Black hills of South Dakota. N. H. Darton.

Tertiary shore lines and deposits in Black hills. N. H. Darton.

Tertiary granite in the northern Cascades, Washington. Geo. Otis Smith and W. C. Mendenhall.

The basin deposits of the Rocky Mountain region. W. M. Davis.

Reconnaissance in southeastern Arizona. E. T. Dumble.

On the age and distribution of the sedimentary rocks of Patagonia. J. H. Hatcher.

Geology of the Wichita mountains. H. Foster Bain.

Volcanics of the Neponset valley, Boston basin. F. Bascon.

Enrichment of mineral veins by later metallic sulphides. Walter Harvey Weed.

Vein formation at Boulder hot springs, Montana. Walter Harvey Weed.

Contact metamorphism of a basic igneous rock. U. S. Grant.

Heronite and its related rocks. A. P. Coleman.

THE GROUP PICTURE of the fellows of the Geological Society of America has recently been distributed to subscribers. The picture includes portraits of 189 American geologists living since 1889. Of these all but ten are now alive, and sixty-six of the present fellows of the society are not included. The central portrait of the group is that of James Hall.

SIR JOHN WILLIAM DAWSON, the oldest and most eminent geologist of Canada, who has been long revered and beloved by geologists throughout all the world, died at his home in Montreal, November 19th. He had just completed his seventy-ninth year, having been born in Pictou, N. S., October 13th, 1820. He received his education at the College of Pictou, and in Edinburgh University. In 1842 he accompanied Sir Charles Lyell in his tour of geologic observations through Nova Scotia. In 1855 he became the principal of McGill College, Montreal, filling also its professorship of natural history. Principal Dawson's energetic and wise direction of this institution continued thirty-eight years, to 1893, during which time it advanced to the front rank of American universities. In an ensuing number we hope to give a sketch of his life and of his services to geology as an observer and as an author, which covered a period of more than fifty years.

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Errata for Volume XXIII.

On page 47, 17th line from the top, for floating read rotating.

Errata for Volume XXIV.

On page 118, 8th line from the bottom, for merely read namely.
On page 176, 16th line from the top, for positively read positive.
On page 349, in the title, read Bates' Pass.

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